NATURE

No. 4081 SATURDAY, JANUARY 17, 1948 Vol. 161

CONTENTS

	Page
Imports of Scientific and Technical Books	75
Transmission in Nerves. By Prof. J. Z. Young, F.R.S.	76
A Study of Japanese Culture. By Peter Lawrence	77
Enzymes in Bacteria. By Dr. H. K. King	78
Chromosome Multiplication and Reduction in Somatic Tissues : Their Possible Relation to Differentiation, 'Reversion' and Sex. By Prof. C. Leonard Huskins	80
Theory of Electrokinetic Effects. By F. Booth	83
Obituaries :	
Dr. Charles Bolton, F.R.S. By Prof. H. P. Himsworth	86
Dr. Emily Barridge. By Dr. E. M. Blackwell	87
Dr. André Kling	87
Prof. J. Masson Gulland, F.R.S.	87
News and Views	88
Letters to the Editors :	
Audio-Frequency Radio Waves from the Sun.—Dr. Donald H. Menzel and Winfield W. Salisbury	91
Showers of Penetrating Particles.—Prof. G. Wataghin	91
Internal Waves in Certain Types of Density Distribution.—Dr. P. Groen	92
Electronic Waves and Thibaud's 'Particles'.—W. E. Benham	93
X-Ray Diffraction Rings from Deformed Solid Metal and Metal Powders.—Dr. W. A. Wood and W. A. Rachinger	93
A Simple Universal Model for Representing the Optic Orientation of Biaxial Crystals.—Dr. N. H. Hartshorne	94
Mode of Action of Acridine Antibacterials.—Dr. Adrien Albert and Reginald Goldacre	95
Arsenolysis and Phosphorolysis of the Amylose and Amylopectin Fractions of Starch.—Dr. Joseph Katz, Dr. W. Z. Hassid and Dr. Michael Doudoroff	96
Reaction of Boric Acid with Polysaccharides.—Dr. H. Deuel, H. Neukom and F. Weber	96
Constitution of Monazite.—Dr. A. W. Wylie	97
Structure of Ures.—Dr. J. O. Harris and A. H. Robson	98
Spread of Detonation in High Explosives.—Elwyn Jones and Dugald Mitchell	98
Chromosome Number of *Sesamum laciniatum* Klein.—Dr. S. Ramanujam and A. B. Joshi	99
Mustard-gas Mutation in *Aspergillus nidulans*.—Donald Hockenhull	100
A Vasodilator, Adrenolytic Substance in Aglomerular Fish Kidney.—Dr. Benjamin Jablons	100
Quantitative Relation Between Salt Accumulation and Salt Respiration in Plant Cells.—Dr. R. N. Robertson and Marjorie Wilkins	101
Aggression, a Component of Post-Epileptic Automatism in *Peromyscus*.—M. R. A. Chance	101
Absorption of Protein and Bacteria from Normal and Infected Joints.—Torbjörn Edlund	102
'Melarsen' and 'Melarsen Oxide'. By J. Williamson and Dr. E. M. Lourie	103
International Study of Rheology	104
Results of the Continuous Use of an Ammonium Phosphate Fertilizer on Rice in Lower Burma. By D. Rhind, O.B.E., and U Tin	105
Nutrition and Cancer. By Dr. E. Boyland	106
Survey of Radio Noise	107

Editorial and Publishing Offices
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number : Whitehall 8831
Telegrams : Phusis Lesquare London
Advertisements should be addressed to
T. G. Scott & Son, Ltd., Talbot House, 9 Arundel Street, London, W.C.2
Telephone : Temple Bar 1942
The annual subscription rate is £4 10 0, payable in advance, inland or Abroad

All rights reserved.

Registered as a Newspaper at the General Post Office

IMPORTS OF SCIENTIFIC AND TECHNICAL BOOKS

As one of the measures deemed necessary for the reduction of British expenditure overseas, and particularly for the conservation of 'dollar' resources, an announcement from the Board of Trade early last autumn re-introduced the system of licensing imports of books and other literature. Certain classes of books were completely excluded, and others, including scientific and technical books, were admitted up to a limiting money value. During the War, the licensing had, of course, been in operation ; but there was the additional need at that time for extreme economy in the use of shipping space, which made restrictions almost inevitable.

Now that import licensing has again been in operation for some months, it is time to take stock of the position. From the first it was obvious that the restrictions, although directed against foreign books generally, would affect chiefly the supply of American publications, for these formed the greater proportion of the literature imported into Great Britain, especially in the fields of science and technology. This made the position particularly serious, for there was a shortage of such literature due to the difficulties of the war years. During that period, potential writers of scientific and engineering text-books in Britain were mostly occupied in work which claimed their whole time and attention, and much of it was done under conditions of secrecy which are only now being relaxed. Further, stocks of standard books had steadily diminished, and lack of labour and of maintenance in the printing works of the country, as well as shortage of paper, prevented—and still prevents—publishers from replenishing them. Thus new works were few and far between, and older books were only available from time to time and often in small numbers, a circumstance which in itself has led to higher costs of production through the increased proportion of overhead costs chargeable to each volume. With the lifting of war-time restrictions, a steady flow of American books into Britain began ; they were welcome, in that many war-time developments of science and industry thus became known for the first time outside the small numbers of those who had been directly concerned in them.

The general terms of the restrictions, so far as they affect scientific and technical publications, were stated in an article in *Nature* of October 4, p. 448. Publishers in Britain are granted licences to import foreign books in bulk up to the value of 100 per cent of their pre-war imports ; in applying for licences, titles of individual books and country of origin must be quoted.

The position of the individual who wishes to purchase a foreign book is, however, not so widely known. Under the present regulations and so far as American scientific and technical literature is concerned, anyone may place an order for books, journals and periodicals with publishers or their agents in the United States, provided the book or journal is imported as a single copy through the post. This permits monthly parts of scientific journals to be

sent to individuals, libraries, etc., in Great Britain. Application for the necessary dollars for purchase money must be made to a bank, or for a money order at a post-office. The order for books, etc., can be sent directly to the United States by the purchaser, or on his behalf by a bookseller, provided the latter is willing to apply for the currency and to arrange for the book or journal to be sent by post directly to the address of the individual placing the order. Within the framework of the general policy of restricting imports of books, the licensing authorities are doing whatever they can to meet the needs of individual purchasers.

Hence the main difficulties at present met by the individual in Britain wishing to purchase American scientific and technical books or to subscribe for American learned periodicals are twofold: he has to make application for the necessary currency, and it is very unlikely that he will be able to examine a book before purchase. In any event, there is bound to be delay in supplying his need.

That an enormous reduction in British expenditure in the 'dollar' areas of the world is necessary will not be gainsaid. Books and periodicals have already made a contribution by the adoption of 'austerity' production methods, including poorer quality and thinner paper, smaller type, smaller margins, etc.; it is sufficient to turn back to a pre-war issue of *Nature* to realize at a glance some of the economies which have been made. The whole policy of restricting the flow of literature should be reconsidered in the light of world affairs.

From the long-term point of view, there never was a time when the free flow of information was so important for world peace and progress. In the turmoil following a great war, the interchange of literature can be a potent factor in promoting mutual understanding and tolerance; and it can prepare the way for the wider knowledge which can only come from the personal visits possible in more settled conditions. In this connexion, there is always the danger that a system of individual licences, although it may be devised solely with the view of controlling expenditure, may become in effect a form of censorship. Whatever the present intention, there seems little to prevent the over-zealous or the doctrinaire who may hold the reins of authority from discriminating against a particular book. This aspect relates particularly to historical and cultural literature, and its significance should not be overlooked at a time when rival political ideologies are threatening to divide the world more effectively than ever before. It is not so important in the field of technology, where the restriction is more likely to be imposed by the exporting country; but the very possibility that a form of censorship can grow out of a licensing system tends to arouse suspicion.

Turning now to the short-term view, there is a strong case for the removal of restrictions on the import into Britain of scientific and technical literature, particularly that from the United States. Publication of recent scientific and industrial developments has been lagging increasingly behind during the war years; and now, when the emphasis is on more and more production, and economy in man-power and processes, it is essential that the most up-to-date information should be available with as little delay as possible. In his presidential address to the Royal Society on December 1, Sir Robert Robinson quoted figures showing the serious time-lag in the publication of the Society's own papers; and he added that other societies were in worse case. The columns of "Letters to the Editors" in *Nature* reflect a similar delay. The President of the Board of Trade has undertaken to assist publications devoted exclusively to research by providing the paper required for prompt production of communications; though there will be difficulty in obtaining labour to enable them to make full use of this concession. Meanwhile, however, there is considerable material of significant value in books and periodicals, of American origin in particular, likely to be of immediate service for the progress of knowledge, in the drive for increased efficiency and in the training of students and technical workers.

It is often said that up-to-date literature is one of the most important tools of the research worker. This is an under-statement; new books and current periodicals are the life-blood of a progressive society. It is hard to believe that the potential value of the knowledge and experience incorporated in books has been weighed against the saving of dollars achieved by limiting imports of literature into Britain to 100 per cent by value—ignoring the substantial increase in prices—of pre-war imports, apart from such purchases as individuals may choose to make.

TRANSMISSION IN NERVES

Die Signalübermittlung im Nerven

By Prof. Alexander v. Muralt. (Lehrbücher und Monographien aus dem Gebiete der Exakten Wissenschaften, Band 14: Reihe der experimentellen Biologie, Band 3.) Pp. 354. (Basel: Verlag Birkhäuser, n.d.) 38.50 Schw. francs.

PROF. v. MURALT and his collaborators in Bern have taken up and developed the technique for the isolation of single frog's nerve fibres invented by the Japanese, Kato and Tasaki. As a result of optical and biochemical investigations of great technical ingenuity he has developed theories about the mechanism of conduction in nerve which might be described as unorthodox. The basic unit of conduction is supposed to be the internode of medullated nerve fibres, and v. Muralt believes that each is separated from the next internode by a transverse membrane at the node of Ranvier. Unfortunately his pictures do not provide decisive evidence of the existence of transverse membranes crossing the entire axon at the node. The optical appearances which they show are well known to histologists and are usually considered as representing the abrupt end of the myelin layer. His belief in the existence of this membrane was strengthened by the observation that in dying fibres it was sometimes seen to be blown out in the direction of one segment or the other. But the figure demonstrating this effect is not convincing and would be taken by most to show a modified portion of myelin

rather than a membrane across the axon. However, the exact details of the node of Ranvier and the nature of the structure called by Cajal the cementing disk still remain very obscure, and v. Muralt's provocative study will certainly stimulate further investigation.

It will be appreciated that if each section of the axon is separated from its neighbours by a complete membrane, all our basic ideas of the neuron as a unit would have to be abandoned; we should be left with each internode as a piece of protoplasm enclosed on all sides by a membrane but not containing a nucleus! It would take much evidence to persuade us of this; a 'membrane' allowing the passage of a 'trophic' influence only and hence dividing the cell into compartments would be a novelty. There is, however, no reason from study of nerve fibres with ordinary methods to suppose that the axon is divided in this way. Preparations fixed and stained in a great variety of ways show that the substance of the axon is continuous across the nodes; it is the myelin which is interrupted. Moreover, if the 'segmented' arrangement is essential for nerve conduction, what is the condition in non-myelinated nerves, large and small, in which we can be as near certain as we can of anything that there are no transverse membranes? Prof. v. Muralt does not ignore this problem, but his solution is to say that the unmedullated fibre is a limiting case in which the whole contents consist of material with "membrane properties". Surely when we speak of a membrane we refer to an entity which separates, and to speak of a fibre as all membrane is repugnant to sense. He admits that this theory "bedarf experimenteller Stutzung, um der sehr spekulativen character zu verlieren"; but will any amount of experiment suffice? His hypothesis is quite categorical that "das Aktionspotential entsteht durch Depolarisation der Quermembran des markhaltigen Nerven" (p. 254). The velocity of conduction is therefore determined by the distance apart of the membranes and the field intensity at them. Such a view is not inconsistent with some of the evidence about the action potential; but unfortunately Sanders and Whitteridge have recently shown that in regenerated nerves, where the nodes are all at small distances apart, the conduction velocity nevertheless increases with diameter as in normal nerves.

With all these doubts we can scarcely for the time being take the theory of the "Quermembran" as the basis for treatment of conduction in nerve. But it would be very unwise to reject v. Muralt's work because it is built around a doubtful hypothesis. The hypotheses are relatively unimportant; what he has done is to devise methods of very great beauty for the measurement of many of the physical and chemical changes which go on in a nerve fibre. Merely to list them is to show the astonishing range of his technical achievement. Included in this book are accounts of a direct current amplifier and methods of measuring the birefringence of nerve, and its X-ray diffraction patterns (unfortunately he does not give any indication whether he has found changes in birefringence of single axons during conduction). Other methods have allowed him to measure the minute chemical outputs of the nerve. Aneurin is estimated by several independent methods, including spectrographic methods and the polarograph, which makes use of the characteristic influences of dissolved substances on mercury-water interfaces. Acetylcholine and potassium are estimated by more conventional methods. He gives us in this book all too few of the actual results of these determinations, but combines his information into a theory of the "action substances" of a nerve. An action substance is any substance necessarily taking part in any particular reaction. Thence for nerve "jeder Stoff, der im Aktionszustand des Nerven gebildet oder verändert wird, und ein unentbehrliches Glied in der Kette der Aktionsreaktionen ist" (p. 272). Acetyl-choline is the first of these substances, and he believes it to be liberated in the activity of all parts of all nerves, including those not cholinergic. Aneurin is also liberated from all nerves and is the second action substance, potassium the third, and A_4, a substance related to aneurin and revealed by the 'polarograph' but not yet identified, is the fourth. An attempt is made to suggest how these four substances liberated from nerve during activity are related to the other changes known to occur. The resulting scheme is one of the most interesting parts of the book but, as the author realizes, speculative to a degree that makes discussion at this stage scarcely possible. It remains to be seen whether this approach to the "action substances" will prove profitable.

As if these physical and chemical considerations were not enough, v. Muralt has also included in his recent work a study of degeneration and regeneration of nerve, again using many methods. One of his most beautiful demonstrations is of the course of the decline in acetyl-choline content during nerve degeneration, beginning as early as the fifth hour and proceeding to zero. Aneurin concentration begins to fall a little later and proceeds only to 45 per cent of normal. Acting upon the presumption that a brain extract should stimulate nerve growth, much study was made of a "neuroregenerative growth-substance", *N R*, able to stimulate regeneration. Methods for estimating rates of regeneration by study of recovery after incision of the rabbit's cornea and after interruption of the phrenic nerve or of the nerves to the whiskers are suggested. Results are given here only for the cornea test; though suggestive they are not satisfactorily demonstrative of a stimulating effect, in view of a very large variability. It is not possible to discuss the possible nature of these substances until the method of extraction is published. It may be that the extracts produce an influence on regeneration of the cornea rather than on the rate of advance of new nerve fibres down the peripheral nerve trunks, no method of accelerating which is known.

This book is evidence of the very great activity of the Hallerianum in Bern during recent years. One is left reeling after such a feast of new techniques and new ideas, and we may hope that v. Muralt will be able to help us recover by astringent doses of further figures and discussions.

J. Z. YOUNG

A STUDY OF JAPANESE CULTURE

The Chrysanthemum and the Sword

Patterns of Japanese Culture. By Ruth Benedict. Pp. vii + 324. (London: Secker and Warburg, Ltd., 1947.) 12*s*. 6*d*. net.

IN her recent book, "The Chrysanthemum and the Sword", Dr. Benedict deals with the Japanese along lines similar to, if not as clearly defined as, those in her earlier "Patterns of Culture". To quote Prof. Franz Boas, she "is concerned rather with the

discovery of fundamental attitudes than with the functional relations of every cultural item". These fundamental attitudes, she believes, colour and condition the whole of Japanese outlook and behaviour.

The author reveals the following fundamental attitudes in the Japanese character: a strict love of social order involving unswerving loyalty to the Emperor and varying degrees of respect or discriminatory behaviour towards each member of society in accordance with his status; a habitual sense of shame coupled with a fear of ridicule and ostracism; a due regard for bodily pleasures, yet a great insistence on self-discipline and a belief in the superiority of the spirit over material power; and finally a complicated and rigid system of obligations and reciprocity. These obligations are the great sanction of Japanese culture; they range from duty to the Emperor, one's parents, family and ancestors to a proper respect for one's good name and reputation (*giri* to one's name). They are especially interesting in that they are eventually concerned with the rite of *seppuku* or *harakiri*.

So far, the work is an excellent general text-book study of Japanese psychology. It is clearly and, so far as one is able to judge, correctly elucidated and interpreted. For example, much of Dr. Benedict's analysis is borne out by Dr. Embree's field study of Suye Mura; and her elaborate description of the sanctions of obligation and reciprocity well explains the virtual pacifist reaction of the Japanese since August 1945. On the other hand, the book suffers from the author's self-confessed lack of first-hand experience in Japan. The system of mutual co-operation in the country districts, stressed so heavily by Dr. Embree, receives scant mention from Dr. Benedict. Its importance cannot be underrated, for refusal of co-operation is a very strong sanction in village life. Moreover, although the above listed fundamental attitudes may be widespread in the urban districts, one wonders how far they strictly apply to the Japanese peasant, "whose primary object", to quote Embree, "is to raise good rice and get along amicably with his neighbours". Such a man, like Falstaff, surely believes that the man who has honour is "he who died o' Wednesday"; and a punctilious observance of "*giri* to one's name" (often culminating in suicide) is something he acquires when he comes into contact with the Army or some other urbanized institution.

Finally, in analysing these fundamental attitudes, Dr. Benedict is rather prone to attribute them to the Japanese, but to minimize them in, or even exclude them from, the nations of the Western world; whereas they exist in both, perhaps emphasized to a different degree. For most of the traits given it would be by no means impossible to find parallels to them among the nations of Europe and even in the United States. It would be hypocritical to deny the existence of a shame complex (as opposed to a sense of guilt) in the West; and the Japanese belief in the superiority of the spirit over material power is reflected in many of our own maxims and proverbs.

It seems, therefore, that we may accept Dr. Benedict's analysis of Japanese fundamental attitudes as substantially true; but that we should be unwise to apply them on too wide a scale. Moreover, we must remember that the differences in outlook that she finds between the Japanese and ourselves are differences of degree rather than of kind.

PETER LAWRENCE

ENZYMES IN BACTERIA

The Chemical Activities of Bacteria

By Dr. Ernest F. Gale. Pp. iv+200. (London: University Tutorial Press, Ltd., 1947.) 8*s*. 6*d*.

IN an age long past, biochemistry was the science of food and waste products, the study, it was unkindly suggested, of the letter-box and the dustbin. The limitations of this approach to the chemistry of life were first discarded half a century ago, when intracellular metabolic enzymes were separated intact from the yeast cell. But though the microbiologist may claim that the science of enzymology (like the name) originated in his field, our knowledge of the cellular chemistry of bacteria lagged far behind the rapid progress made with yeast and animal tissues. Only during the last decade have the technical difficulties of extracting intracellular enzymes from the bacterial cell been overcome; at the same time, the usefulness of the washed suspension technique (employing intact cells) has been much enhanced by such tools as the deficient-culture technique and isotope methods. How rapidly the investigators of bacterial metabolism have made up the lost ground will amaze even those readers of Dr. Gale's book who are familiar with this field. But the intensive study of individual metabolic processes must not lead to neglect of the larger physiological system of which they are but the component parts. The bacterial cell is more than "a collection of enzymes surrounded by a semipermeable membrane".

One fundamental problem is kept continually before the reader, however. The reaction of the organism to its environment is peculiarly suitable for study among micro-organisms, since the environment may be precisely defined in simple chemical terms and the organism responds very rapidly, natural selection taking place within a community within a matter of hours. Dr. Gale himself has made extensive study of the relation between enzymic constitution and environment and the part this plays in the continued life of the organism in changing and perhaps unfavourable circumstances. But it is difficult always to avoid 'missing the wood for the trees'. Thus adenosinetriphosphate, once regarded simply as a 'phosphate-carrier', is now known to be the one essential product of perhaps the majority of catabolic processes. Text-books seldom give this vital point the emphasis it deserves, and the student may puzzle his way through the complex chemical cycles by which the bacterium produces its 'acid and gas' without fully realizing what it is all for. The specialist, of course, knows already: and it is essentially for the specialist that this book is written.

Dr. Gale has done a great service by collecting and critically examining much scattered material within a small space. He has achieved this by confining himself mainly to those topics (and they are many) on which he can claim to speak with acknowledged authority. Others are dealt with more briefly; but the reader is directed to authoritative reviews through a small number of carefully selected references. Duplication is thus avoided, but at the risk of giving the student an unbalanced view. Preliminary chapters make the book complete by introducing the non-bacteriological reader to the bacterial world (yeasts and moulds are not dealt with in this book), while a final chapter on the practical details of bacteriological technique invites him into a field peculiarly full of pitfalls for the unwary.

H. K. KING

Surveying for Young Engineers

By S. Wright Perrott. Pp. viii + 232. (London: Chapman and Hall, Ltd., 1946.) 10*s*. 6*d*. net.

THIS book is a revised and greatly enlarged edition of the author's "Surveying for Schools", originally published in 1930. It is designed to give practical assistance to the young and inexperienced surveyor. The author has thus wisely widened the scope of his earlier volume in order to provide a more complete exposition of the subject, while still concentrating upon the practical point of view in dealing with the field and office work. The text consists of twenty-eight chapters devoted to the practical methods employed in making surveys, an explanation of the necessary instruments, and the preparation of relevant plans. Some good advice is given on the important work of checking, and the book is excellently illustrated by drawings, maps and plates depicting some of the instruments to be used. No instrument, however, is described until its practical use has been fully explained. A useful index is included; but no exercises are provided since the course is intended mainly for practical field work. Formal mathematical treatment has also been avoided—the only form of calculation needed being simple arithmetic.

As the author points out, most of the text-books on the subject are academic productions, planned with a view to examination requirements; but the field is the right place in which to lay the foundation of surveying. Hence, the emphasis on practical outdoor work.

The book is well printed and got up, and should be of much use to those beginning the study of surveying.

Elements of Mechanism

By Peter Schwamb, Allyne L. Merrill and Walter H. James. Sixth edition, revised by Prof. Venton Levy Doughtie. Pp. xi + 428. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1947.) 4 dollars.

THIS somewhat unusual type of text-book originated in 1885 from printed notes used by Prof. Peter Schwamb at the Massachusetts Institute of Technology. In its present form, the book is in thirteen chapters dealing with motion, vectors, velocity, acceleration, linkages, transmission of motion by direct contact, cams, rolling contact, gears, trains of wheels, belts, ropes, chains, pulley blocks, screws, screw threads, pawls, escapements, etc. The whole course thus provides an authoritative book on the fundamental principles of kinematics applied to mechanical movements. In this edition, not only have recent data on the subject been added, but also laboratory problems emphasizing practical applications of theory are included for the first time.

As Prof. James points out in the preface to the fifth edition, "A study of the elements of mechanisms . . . is intended primarily to give the student familiarity with, and practice in thinking about, the application of the fundamental principles of kinematics in a specific field, namely, the field of mechanical movements".

The text is, in relevant sections, treated mathematically, frequent use being made of the simpler methods of the calculus, and is profusely illustrated both by clearly drawn diagrams and blocks lent by manufacturers. An index is provided; but no answers to the problems are given as solutions are expected to be done graphically. The whole course has been skilfully mapped out in an interesting manner and should be of much use to technical students.

F. G. W. BROWN

Hydraulic Measurements

A Manual for Engineers. By Prof. Herbert Addison. Second edition, revised and enlarged. Pp. xii + 327. (London: Chapman and Hall, Ltd., 1946.) 21*s*. net.

THE need for a second edition of this admirable manual within a relatively short time amply justifies the encomiums which were paid to the first edition on its publication in 1940. It was, in fact, an appropriate and even a necessary adjunct to the same author's "Text Book of Applied Hydraulics", and clearly it has been found helpful by a number of engineers and students engaged on problems connected with liquid flow. The opportunity has been taken to amplify the original text by adding some new paragraphs to improve the balance of the work, and at the same time to bring it up to date. These additions have been introduced in such a way as not to disturb the arrangement of the original material, which remains unaltered. Hydraulics is largely an empirical science, and the application of reliable standards of measurement is necessary to its satisfactory development. New methods, some of them indirect, as in the case of the Allen salt-velocity principle, are continually being evolved, and, among other recent improvements, the author notes the adoption of standardized forms of pipe inlet in the Annis suction pipe meter now being used in that type of differential head meter. The manual will be found enhanced in usefulness by its revision and extension.

B. C.

The Yale Collections

By Wilmarth S. Lewis. (Published on the Foundation established in Memory of Curtis Seaman Read of the Class of 1918 Yale College.) Pp. xv + 54 + 13 plates. (New Haven: Yale University Press; London: Oxford University Press, 1946.) 11*s*. 6*d*. net.

YALE was founded on a collection of books. This short survey of the collections of books, manuscripts, objects of art, natural history and anthropology which have come to Yale during the past two and a half centuries has been written to indicate their extent and variety, which are not generally known even in New Haven. If the library is the heart of a university, the other collections are the basic food of research. It is therefore sad to see that the author finds it necessary to justify the existence of "what many consider a frill". The survey briefly describes the history and contents of the library and its specialized collections, the art gallery, the Peabody Museum and the Anthropology Museum. It has space to mention only by name many other valuable collections and the splendid researches which have resulted from their study. The illustrations include an interesting photograph of a restoration of the first Yale College library as it was in 1742, with the actual books presented by Newton, Halley, Bishop Berkeley and others on the shelves.

The printing, paper and make-up of the volume are worthy of their subject, but the text contains a number of colloquialisms that jar on British ears.

L. HARRISON MATTHEWS

CHROMOSOME MULTIPLICATION AND REDUCTION IN SOMATIC TISSUES

THEIR POSSIBLE RELATION TO DIFFERENTIATION, 'REVERSION' AND SEX

By Prof. C. LEONARD HUSKINS
University of Wisconsin

CYTOLOGY, which began as a purely descriptive science, bifurcated early in this century into 'karyology' and 'experimental cytology'. By 1925 the karyologists had, as Schrader[1] points out, assembled a mass of data with far too few unifying concepts. These were furnished in the period 1925–35 by a closer union with genetics, in which John Belling and C. D. Darlington[2] played predominant parts, and cytogenetics became the most rapidly developing branch of cytology. When in 1942, as a Guggenheim Fellow, I attempted to write an advanced text-book I began with the assumption, then common to most cytogeneticists, that a synthesis was possible on the basis of generally accepted theories, with only minor modifications and adequate citation of exceptions. I ended with the opinion (cf. ref. 1) that some of the exceptions no longer 'proved the rule' but rather demanded basic revisions of the theories[3]. Of the new research approaches that seemed necessary, one promising line open to the cytologist appeared to lie in the union of cytogenetics with experimental cytology.

A beginning was made at McGill University in collaboration with Prof. George Scarth and a joint student, Herbert Stern[4,5]. The War, and at its end Scarth's retirement, deferred developments. A year ago it became possible to begin assembly of a research team at the University of Wisconsin, and a programme was initiated. Two features of it: (*a*) the determination of chromosome constitution in differentiated tissues, and (*b*) the experimental production of meiotic ('sexual') divisions in somatic tissues, have reached a stage at which the basic discoveries may be outlined and their possible significance discussed.

It is now well known to cytologists, though not yet taken into account by most biologists[6,7], that many animal and plant tissues are characteristically polyploid or polytene (any distinction between these is in part arbitrary, and in any event lacks significance for issues considered herein; both may, presently, be termed polysomaty or endopolyploidy). Geitler, who earlier did much of the best work on animal tissues, in 1940[8] recorded polysomaty in thirteen plant species and eleven tissues of these, including infected ones. He concluded, however, that no generalizations could be made regarding its significance since: (*a*) the data are too scattered, and (*b*) we know that differentiation can proceed either with increase in cell size, and therefore possible polysomaty, or by increase in cell number with all cells presumably remaining diploid. Since 1940 many new cases of polysomaty have been reported, including the very recent ones in flower-buds and succulent leaves by Geitler's students Lauber[9] and Jähnl[10]; but no possible rationale for their occurrence has been suggested other than our own[11]. White[12] sums up the situation in animals as follows: "The whole process of histological differentiation in insects seems to be intimately bound up with this phenomenon of endopolyploidy, each organ and tissue having its own characteristic degree of ploidy, some being entirely composed of one type of cell while others are mosaics of cells with different multiples of the fundamental diploid number. To what extent endopolyploidy occurs outside the Insecta is not known at present, but there are indications that it is fairly widespread in many groups of animals. In the vertebrates conditions are not favourable for counting the chromosomes in somatic resting nuclei, but measurements of nuclear volumes (Jacobj 1925–1935) suggest that in some mammalian tissues several size classes of nuclei exist, and it is possible that these correspond to different degrees of polyploidy."

TABLE 1

HETEROCHROMATIC BODIES IN RESTING NUCLEI OF *Rhœo discolor*

Mm. from tip	No. of nuclei	Mean No. hetero.	*S. D.* *M*	Variance
1	190	11·1	2·11	4·47
2	100	12·1	2·8	7·81
3	99	18·1	4·7	22·09
4	101	20·6	4·97	24·74
5	101	21·3	5·02	25·29

Differences of means: 1 : 2, not significant
1 : 3, not significant
1 : 4, 9·5 ± 4·74 $P = 0.045$
1 : 5, 10·2 ± 4·79 $P = 0.04$–0.03

In 1946 we began, with a possible rationale in mind, an investigation of the extent of polysomaty in plant tissues commonly assumed to be diploid. Roots of *Rhœo* were chosen for a first test as these have, in their chromosomes, heterochromatic regions that can be stained in energic ('resting') nuclei. These first studies, with L. Steinitz[11], indicated that a very large proportion of differentiated cells behind the meristematic region are polysomatic (see Table 1). The test is, however, too indefinite and too subjective, particularly because the heterochromatic regions vary so much in size and fuse so readily. To count the actual chromosomes it is necessary to induce mitosis in cells that ordinarily would probably not divide again. It is, however, then necessary to avoid the induction of polysomaty by the treatment employed. Indole-3-acetic acid in dosages which we consider meet this latter requirement have enabled us to determine that 25–35 (maximum 75 in one root) per cent of the differentiated cells *that are induced to divide* in *Rhœo* roots are polysomatic. (The data of Table 1 indicate that, if all cells could be induced to divide, the proportion seen to be polyploid would be much higher.) We also found both statistical (Table 2) and direct (pairing with chiasma formation) evidence that reduction occurs from polyploidy to diploidy, as Berger[13] found in *Culex*, and we saw several haploid nuclei[11,14].

Repetition of the experiments, by Rhona Leonard, on barley gave similar results. At the same time, it was found by R. E. Duncan and J. G. Ross that the older nuclei of untreated maize endosperm are polytene[11]. The total data on polysomaty now make it clear that the axiom that all cells of a plant or animal body have the same chromosome and genic constitution is, quantitatively at least, invalid. In exceptional cases involving 'chromatin diminution' it has long been known that it may be invalid qualitatively, though the presumed absence of genes in heterochromatin complicates this issue. We have under way tests which may possibly help to determine whether, in a more sophisticated sense dependent on a concept of gene structure developed later herein, it lacks general validity.

TABLE 2

Treatment	No. of roots	Hours after treatment	Region	Chromosome number									Per cent polyploid
				n	$2n$				$4n$		$5n$	$6n$	$8n$	
				Chromatid number per chromosome										
				2	2	4	6	8	2	4	2	2	2	
Rhœo discolor	6	0–6	Meristem		22									0
Indole-acetic acid			Diff'd		28									0
20 p.p.m. 4 hours	8	7–12	Meristem		398									0
			Diff'd		72	15			3					20·0
	4	13–18	Meristem		114									0
			Diff'd		556	180			93	2			2	33·2
	3	19–21	Meristem		228									0
			Diff'd	2	349	175			69	8	2?			41·9
	4	22–24	Meristem		224									0
			Diff'd		243	35			46					25·0
Barley	2	0–3	Meristem		1									0
Indole-acetic acid			Diff'd		0									0
20 p.p.m. 4 hours	3	4–9	Meristem		167									0
			Diff'd		25	5			5					28·6
	4	10–15	Meristem		169									0
			Diff'd		47	20			1					30·9
	7	16–21	Meristem		420									0
			Diff'd		158	35	1	2	26	1			1	29·5
	2	22–28	Meristem		124									0
			Diff'd		70	10		3	6	1			2	23·9
40 p.p.m. 4 hours	3	21–28	Meristem		96									0
			Diff'd		82	12			4			2		18·0

Caspersson[15] found that at pachytene of meiosis when the paired chromosomes become microscopically four-partite there is a very high nucleic acid content. His conclusion "that nucleic acid plays a role in the synapsis or in the division of the chromonemata or in both" seems basically sound. His further conclusion[16] that thymonucleic acid has a role in gene reduplication is, however, based on the premature, if not completely inacceptable[17], identification of chromosome substance with gene and the view that gene reproduction and chromonema splitting coincide. This latter is one of the commonly accepted concepts of cytogenetics that has long seemed to require reconsideration. More than fifteen years ago Nebel, McClintock, Huskins and Smith and others (see ref. 18) showed cytologically that each chromatid in a meiotic tetrad is at least a double, if not a multiple structure, though it behaves as a unit in genetic segregation and usually, if not always as is commonly assumed[2], in its breakage and mutational response to X-radiation. Nebel[19] and I also had what we considered clear evidence of doubleness before pairing. Further, for more than twenty years many of the most cautious cytologists (see ref. 20) have held that the chromosomes of somatic divisions are double at anaphase and therefore contain twice as many strands as genetic evidence leads us to expect. (That the same opinion has also been held on faulty grounds is irrelevant.)

In meristematic cells of onion root-tips treated with sodium ribose nucleate (Swartz Lab. Inc. Sample *SN* 4509) by M. Kodani[21] in the course of his studies on the effects of nucleic acids and related compounds on the production of 'lampbrush' chromosomes, I recently found chromosome pairing and reduction divisions, similar in essential respects to those of the germ cells. It should be stressed that, as mentioned above, we had previously found several cases of reductional divisions in differentiated tissues in our indole-3-acetic treated materials, and with Caspersson's conclusions in mind I was looking for them in these slides. Otherwise, for the reasons given below, they would probably have been missed in the initial slides in which they occurred rather infrequently. By using 4 per cent sodium nucleate solution for 5–19 hours Kodani increased the number to several per cent of the total number of dividing cells and made it possible for us to make a detailed analysis.

The possibility that only chance association and distribution of chromosomes was involved has been eliminated by L. Steinitz in experiments on *Rhœo* roots. In them catenations of several chromosomes, instead of simple pairs, occur as in their germ cells. An 8 per cent solution for six hours has produced this effect in the majority of dividing nuclei.

Some of the pairing in onion roots is with chiasmata, some without. Further tests using structurally modified homologous chromosomes, which will bear on the chiasma-crossing-over relationship, are therefore under way.

From consideration of the cytological literature and our own, unpublished, data and especially since the recent evidence of somatic reduction in cotton[22], we conclude that our sodium nucleate treatments have only increased the frequency, by abnormal dosage with substances normally present, of a process that occurs naturally but infrequently without treatment. When pairing and reduction-type divisions occur in large numbers, as in our later experiments, they cannot long be missed. If they occur only occasionally, as in normal material, they would usually be missed by the cytologist for two reasons: (*a*) spindle formation and kinomere orientation on it are abnormal and the general appearance of the first reductional division is that of a cell squashed in preparation; (*b*) the second division is commonly abortive. When abortive, two nuclei are formed, each with the normal diploid chromosome number (instead of four with the haploid number as when they are not abortive), and in a structurally homozygous organism these two nuclei are indistinguishable, to the cytologist, from the products of a normal mitosis. In a genetically heterozygous organism, however, the result would be seen, as somatic segregation or 'crossing-over' for two homozygous cells, one with the two dominants and the other with the two recessive factors, can result. It is possible that many of the known cases of somatic segregation and/or crossing-over in *Drosophila*, other animals and plants occur in this way. The demonstration of this mechanism may further have significance for the phenomenon of 'saltation' in fungi lacking known sexual stages, and perhaps in bacteria[24].

Sometimes one of the two reduced nuclei divides before the other and before a cell wall is formed between them—as it often does in pollen mother-cell meiosis. This gives sixteen chromosomes at one end of the cell and eight at the other, and, of course, furnishes particularly convincing evidence that a true reduction division and not merely a random segregation of chromosomes has taken place.

The observations render more acceptable the oft-reported cases of chromosome pairing in tumours, particularly since a high nucleic acid content has been found in many tumours. In itself this may be quite distinct from any question of the *origin* of the tumours. However, in so far as the somatic cell mutation theory of cancer is acceptable, our observations indicate that such 'mutation' may well be somatic segregation in an organism heterozygous for a gene or genes that predispose to tumour susceptibility. The recent work of Greenstein[35] and Potter *et al.*[36] indicates that the changes involved are enzymatic in nature, as are the effects of many gene changes.

Sporadic cases of genome segregation, of which those in strawberries[37] and oats[38] are the most striking, also receive one highly plausible rationale from our observations. To get segregation of ancestral genomes from an allopolyploid it is theoretically necessary only to have pairing and segregation of homologous chromosomes in somatic tissue of the germ track prior to a normal meiosis in which there is pairing and segregation of the ancestral homœologues as in the hybrid diploid ancestor. Experiments are therefore being set up in which we shall attempt to abstract ancestral species from polyploids. This may have a bearing on the currently highly controversial[39] problem of 'relic' species.

The simple cytogenetic concept of the chromatid as a unitary string of genes seems to be entirely adequate for crossing-over and the Mendelian transmission of hereditary differences, though not as much so for the data on the production of such differences as is commonly supposed (cf. mosaics). Along with its corollary, the earlier concept of the gene as a unitary organic molecule, it has been a hindrance to thought on the gene as a physiological unit. It is now clear that the gene which acts as a unit in genetic segregation must in some sense be a multiple unit, since its microscopically visible habitat, the chromatid, is at least double. Current concepts of the protein molecule as made up of a number of identical lamellæ give us a model for the gene that seems to fit all present cytological and genetic data and open up the way for new theories of gene action. In particular they permit us to investigate the simplest of all possible hypotheses—and, as Muller[10] points out, one of the earliest—namely, that the gene acts as a physiological unit just as it does in inheritance by reproducing itself, or, more specifically, its platelets. (By using the term 'gene' to refer, for the present, either to a platelet or a multiplicity of platelets we are adding only one new concept to the several already subsumed under that term.) The axiom of chromosome and genic identity of all cells in a plant and animal body, which is now shown to be an incomplete and perhaps misleading concept, has previously prevented serious consideration of this hypothesis—see Wright[21], in which he points out that on the accepted theories of gene structure and identity of all cells a gene could reproduce itself only once between each nuclear division. This limitation as applied to platelets no longer holds. The discovery of nuclei with chromosome, and especially chromatid, numbers other than an exponential power of two (Table 2) may be of very great, though indirect, significance in this connexion. The next and most difficult step in the testing of this hypothesis is to determine whether all parts of a chromosome and all genes reproduce at the same rate. There is already much evidence that heterochromatin and 'differential regions' do not—included in this evidence is that of R. E. Duncan[33], who has further unpublished data that fall in line.

The concept we currently favour is that the gene, and its visible manifestation or habitat the chromatid segment or 'chromomere', must continuously be reproducing itself in all living tissues by the production of new platelets. Failure to do so would be one means of 'chromatin diminution'. Possibly this is what Goldschmidt has in mind[39] when he remarks that it occurs only in organisms with a limited cellular reproduction.

Wright[21] has pointed out that a mutation in one of the postulated lamellæ of a gene may (conceivably by "the same mechanism as involved in the duplication process") be restored rapidly or spread through them all. Gulick[17] considers this highly probable and adds that since genetic stability is founded on stability of chromosome organisation, natural selection will be expected to have ensured that restoration occurs in the majority of cases. The relative rarity of mosaicism is therefore expected even on the lamellar hypothesis of gene structure, while its occasional occurrence is thereby readily explained.

It may well be, of course, that polysomaty is not so direct an indication of the mode of gene action as the present hypothesis postulates. That it has *some* relation to the physiological activity of the gene now seems self-evident. Since the above data on higher plants, insects, and mammals were evaluated there have come to hand the papers of Subramaniam[34] claiming a relationship of "endopolyploidy" to enzymatic activity in yeasts and indicating its probable significance in the macronucleus of ciliates. It begins to look as if continued mitoses are essential to the preservation of diploidy. The significance of this possibility for theories on the isolation of the germ plasm are obvious.

To summarize the argument from the data on somatic reduction: A combination of four steps, each of which is now firmly established as occurring normally (and with higher frequency in experiments with normally occurring environmental substances or influences in unusual dosages but within a range consistent with viability), is sufficient to account, theoretically at least, for all the basic cytogenetic and evolutionary features of sex. They are, to state a hypothetical case for the purpose of exposition: (1) endomitosis (as an alternative to the nuclear fusion usually proposed) in a haploid organism giving rise to diploid tissue; (2) complementary mutations (it is, for the moment, irrelevant whether genic or chromosomal) in the two sets of chromosomes which render either one individually less efficient than the combination of both; (3) somatic reduction, with or without crossing-over; (4) fusion of reduced nuclei (or, in dikaryonts, of cells). These give us the cytogenetic essentials of sex without sexes or sexuality. All successive developments of sexuality may be viewed as adaptive mechanisms facilitating the orderly sequence of the reduction and fusion. On this simple view 'incompatibility' reactions are the evolutionary forerunner of ordinary sexuality, though reversion can, obviously, occur. The number of

complementary heterothallic forms is unlimited; the number of true sexes is limited to two because there must be very close association of many adaptive features. All the above issues have, of course, been considered by many writers and especially clearly by Darlington[34]. Beadle's[35] scheme has similarities but also fundamental differences; he, further, accepts Darlington's conclusion that nuclear fusion and meiosis must have arisen simultaneously, which is not necessary in the above scheme. Our contribution, regardless of hypothetical significance, is the experimental production of the third, and previously most inexplicable, step, and from Stern's[5] work a suggested experimental technique for the production of fusion within a single organism. Our scheme has one advantage over others in that somatic reduction may in some cases (cf. ref. 22) have immediate selective value for the tissue involved and not only for the progeny[36].

To conclude, the occurrence of polysomaty and polyteny in differentiated tissues and of somatic reduction divisions equivalent to both complete and incomplete meiosis are established, and also the optical doubleness (if not the multi-strandedness) of the chromatid which is nevertheless the *unit* of Mendelian segregation. The speculations on the possible significance of the data are predominantly of the nature of working hypotheses which can, though to very varying degrees, be tested. Their validity, or lack of it, at this stage is therefore immaterial to their possible usefulness. Further obvious speculations on issues such as the relationship of the postulated platelets to 'plasmagenes', etc., are not indulged in since we see at present no way for the cytogeneticist to test them.

It must be emphasized that though I accept full and sole responsibility for all statements above, the work is that of a team in which I have the collaboration of three senior and seven junior associates. In the detailed publications to follow, authorship and accrediting will indicate the particular contributions of each in so far as this is possible with a team the members of which, to end on a cytological analogy, are, like cells, individual units at the level of differentiation, that is, in their special studies, and sub-units at the integrative level, that is, in the general programme. Financial support is provided by the Wisconsin Alumni Research Foundation and, through the award of one fellowship, by the National Research Council, Committee on Growth.

[1] Schrader, F., Presidential Address, Section F, *Amer. Assoc. Adv. Sci.* (1947).
[2] Darlington, C. D., "Recent Advances in Cytology" (Churchill, 1937).
[3] Huskins, C. L., *J. Hered.*, **35**, 81 (1944); **36**, 43 (1946).
[4] Stern, H., *Trans. Roy. Soc. Canada*, **40**, 141 (1946).
[5] Stern, H., *J. Hered.*, **37**, 46 (1946).
[6] Glaser, O., *Trans. New York Acad. Sci.*, **4**, 5 (1941).
[7] Sinnott, E. W., and Bloch, R., *Amer. J. Bot.*, **33**, 587 (1946).
[8] Geitler, L., *Ber. Deutsch Bot. Ges.*, **58**, 131 (1940).
[9] Lauber, Henriette, *Ost. Bot. Z.*, **94**, 30 (1947).
[10] Jähni, Gertrud, *Chromosoma*, **3**, 48 (1947).
[11] Huskins, C. L., *Proc. Roy. Soc. Canada* (1947).
[12] White, M. J. D., "Animal Cytology and Evolution" (Cambridge Univ. Press, 1945).
[13] Berger, C. A., Pub. Carnegie Inst., Washington, 496 (1938).
[14] Huskins, C. L. (Discussion Cold Spring Harbor Symposium, June 1947, in the press).
[15] Caspersson, T., *Arch. Exp. Zellf.*, **22**, 655 (1939).
[16] Caspersson, T., *Chromosoma*, **1**, 147 (1939).
[17] Gulick, Addison, *Bot. Rev.*, **7**, 433 (1941) (and personal conversation).
[18] Sharp, L. W., "Introduction to Cytology" (McGraw-Hill Book Co., 1934).
[19] Nebel, B. R., *Z. Zellf. Mikr. Anat.*, **16**, 251 (1932).
[20] Kaufmann, B. P., *Amer. J. Bot.*, **13**, 59 (1926); *Bot. Rev.*, in the press.
[21] Kodani, M. (in the press).
[22] Brown, Meta A., *Amer. J. Bot.*, **34**, 384 (1947).
[23] Stern, Curt, *Genetics*, **21**, 625 (1936).
[24] Lederberg, J., and Tatum, E. L., *Nature*, **158**, 558 (1946).
[25] Greenstein, J. R., "Biochemistry of Cancer" (Acad. Press. N.Y., 1947).
[26] Potter, V. R., IVth Int. Symp. on Cancer (in the press, 1947).
[27] East, E. M., *Genetics*, **19**, 167 (1934).
[28] Nishiyama, I., *Cytologia*, **5**, 146 (1933).
[29] Rousseau, J., *Ecol. Soc. America*, Amer. Assoc. Adv. Sci. meeting (1947).
[30] Muller, H. J., *Proc. Roy. Soc.*. B, **134**, 1 (1947).
[31] Wright, Sewall, *Amer. Nat.*, **79**, 289 (1945).
[32] Duncan, R. E., *Amer. J. Bot.*, **32**, 506 (1945).
[33] Goldschmidt, R., and Teh Ping Lin, *Science*, **105**, 619 (1947).
[34] Subramaniam, M. K., *Curr. Sci.*, **16**, 157, 228 (1947).
[35] Beadle, G. W., and Coonradt, Verna L., *Genetics*, **29**, 291 (1944).
[36] Darlington, C. D., "The Evolution of Genetic Systems" (Cambridge Univ. Press, 1939).

THEORY OF ELECTROKINETIC EFFECTS

By F. BOOTH

H. H. Wills Physical Laboratory, University of Bristol

THE purpose of this article is to summarize the present position of the theory of electrokinetic phenomena and to present certain new mathematical results I have obtained, the details of which will be published later.

In electrokinetic phenomena we are concerned always with the electrical double layer at the boundary between an electrolyte and a solid. Two types of theoretical problem arise in considering the effects of this double layer, depending upon whether equilibrium, or non-equilibrium irreversible conditions (in the thermodynamic sense), prevail. An example of the first type of problem is the determination of the mechanical force between two solid particles at rest immersed in an electrolyte also at rest. This problem, of fundamental importance in colloid chemistry, has been solved successfully by Verwey[1] after many abortive attempts by other workers. The second type constitutes the subject matter of this article; here dynamic rather than static conditions prevail, and we have to determine various consequences of the effect of the double layer on the flow of an electrolyte past a solid surface. These electrokinetic effects have, apart from their intrinsic interest, important industrial and biological applications[2]. The main electrokinetic phenomena are:

1. *Cataphoresis or electrophoresis*; this is the motion of the particles in a suspension when an electric field is applied (Reuss, 1808).

2. *Electro-osmosis*; this is the flow of a liquid through a capillary when an electric field is applied parallel to its axis. Closely related is the effect known as *electro-osmotic pressure*; if the flow through a horizontal capillary is prevented, a difference of pressure develops between the ends when the field is applied (R. Porret, 1816).

3. *Streaming potentials*; the potential set up between the ends of a capillary when an electrolyte is forced through it (Quincke, 1859).

4. *Sedimentation potentials.* A suspension of particles, if allowed to settle, sets up a vertical electric field (Dorn, 1878). A very similar effect is the difference of potential which develops between the nodes and antinodes set up by stationary sound waves in a suspension (see, for example, Hermans[3]).

5. *Electroviscous effect*; this is the increase of the effective viscosity of a solid suspension owing to the double layer on the particles.

Other effects may be suggested; for example, the double layer must influence the rate of diffusion of particles in suspension.

The classical theory of effects (1) to (4) is due to Helmholtz[4] and Smoluchowski[5]. For electro-osmosis they gave, for the mean velocity of flow,

$$\bar{v} = \frac{E\varepsilon\zeta}{4\pi\eta}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Here E is the field-strength, ε the dielectric constant of the liquid, ζ the potential difference across the double layer, η the coefficient of viscosity. Smoluchowski's contribution was to insert ε in (1) and to show that the assumption for the capillary, of a uniform cross-section normal to E, could be discarded. Thus (1) holds for a closely packed powder with electrolyte filling the interstices. It is thus easily seen that the velocity U of cataphoresis will also be given by (1), U replacing $\bar{v}$, and ζ now being the electrokinetic potential of the particles. For, suppose we have a fixed but *isolated* particle; at a large distance the mean streaming velocity will be given by (1). But this system is equivalent to a *stationary* liquid and a *moving* particle.

The field set up in streaming potentials is

$$E = \frac{\varepsilon p\zeta}{4\pi\eta\sigma}, \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where p is the pressure gradient and σ the specific conductivity of the electrolyte. By an argument very similar to that we used to relate U to $\bar{v}$, equation (2) can be used to find the field set up in sedimentation. This is

$$E = \frac{1}{3}\frac{\varepsilon\zeta g\,(\Delta - \Delta')}{\pi\sigma\eta}, \quad . \quad . \quad . \quad . \quad (2')$$

Δ being the particle density and Δ' the fluid density.

These formulæ only apply provided that the thickness of the double layer at each point of the interface is *small* compared with the radius of curvature at that point.

Although the Helmholtz–Smoluchowski formulæ have been extensively used for the analysis of experiments, they have undergone considerable criticism and modification in recent years. Let us first examine the phenomenon of cataphoresis; physically, this is the simplest effect but it is the most difficult one to treat mathematically. One obvious limitation of the Helmholtz–Smoluchowski theory is the restriction on the thickness of the double layer. This is not likely to be serious in effects (2) and (3), but evidently may not apply in cases (1), (4) and (5) for very small particles. For cataphoresis, Henry[6] obtained a formula which did not require this restriction on the thickness of the double layer. For non-conducting spherical particles he obtained

$$U = \frac{\varepsilon E\zeta}{6\pi\eta}\left[1 + \frac{1}{16}b^2 - \frac{5}{48}b^3 - \frac{1}{96}b^4 + \frac{1}{96}b^5 + \frac{1}{8}b^4 e^b\, E_i(b)\left(1 - \frac{b^2}{12}\right)\right], \quad . \quad . \quad . \quad (3)$$

where $E_i(x) = \int_x^\infty \frac{e^{-u}}{u}du$, $b = \chi a$, a is the particle radius, and

$$\chi^2 = \frac{4\cdot e^2}{\varepsilon kT}\sum_{i=1}^{s} n_i z_i^2.$$

The summation is over the s ionic species present in the electrolyte, n_i being the concentration, z_i the valency. Since χ^{-1} is a measure of the double layer thickness, b represents the ratio of the radius a to this thickness. The function in brackets tends to 3/2 for b large, and to 1 for b small; hence in the limit (3) agrees with Smoluchowski's formula.

Henry's treatment, however, contains a serious blemish, for in order to obtain (3), he had to assume that the charge distributions on the surface and in the electrolyte remain spherically symmetrical when the field is applied; this is certainly incorrect, since the ions will tend to fall behind the particle, causing excess of charge there and a deficit in front, as compared with the equilibrium charge density. This behaviour is known as the 'relaxation effect' in the theory of electrolytes.

Various attempts have been made to remedy this defect; one by Hermans[7] and another by Komagata[8] are valueless since they contain fundamental mistakes. More recently, Overbeek[9] and, independently, the present writer[10], have given generalizations of Henry's formula. I find a general expression for U in the form

$$U = \frac{EeQ}{6\pi\eta a}X_1(b) + \frac{E}{6\pi\eta}\sum_{r=2}^{\infty} Q^r e^{2r-1}a^{-r}(\varepsilon kT)^{1-r}\,[q_r X_r(b) + Y_r(b\,q_\mu t) + Z_r(b, q_\mu q_\mu^* t)]. \quad (4)$$

Qe denotes the total charge on the particle when at rest, q_μ the set $(q_2, \ldots q_r)$, q_μ^* the set $(q_2^*, \ldots q_r^*)$; also

$$q_r = \sum_{i=1}^{s} n_i z_i^{r+1} \Big/ \sum_{i=1}^{s} n_i z_i^2, \text{ and}$$

$$q_r^* = \varepsilon kT \sum_{i=1}^{s} n_i z_i^{r-1} w_i^{-1} \Big/ \pi\eta e^2 \sum_{i=1}^{s} n_i z_i^2,$$

where w_i is the ionic mobility of the ion of type i. The functions X_r, Y_r and Z_r are very complicated, although it can be shown that they all, except X_1, tend to zero as b tends to zero or to infinity; the X_r are functions of b only, but Y_r and Z_r may contain certain surface parameters which we have indicated by t in (4). The physical significance of the three terms in the square brackets is as follows: X_r represents a contribution to U due to the *symmetrical* part of the field around the particle. These terms, when r is greater than 1, do not appear in Henry's formula (which is identical with the first term of (4)) because he adopted the Debye–Hückel approximation, namely, that $\zeta e/kT \ll 1$; $\zeta e/kT$ may reach values of about 4, so that this approximation is not good. Y_r represents a contribution to U due to the distortion of the field, but *not* involving the ionic mobilities; that is, distortion not due to relaxation; Z_r is the contribution due to relaxation. So far, the expansion has been worked out as far as the Q^4 terms for *symmetrical* electrolytes (that is, electrolytes with equal numbers of positive and negative ions, or with $q_{2r} = 0$), though work is proceeding on the more difficult case of unsymmetrical electrolytes.

To obtain formula (4) it is first necessary to derive the spherically symmetrical part of the field. At distance r from the centre, the potential of this field is found to be

$$\psi_1 = \sum_{m=1}^{\infty} Q^m e^{2m-1}(\varepsilon a)^{-m}(-kT)^{1-m}\lambda_m(\chi r). \quad . \quad . \quad (5)$$

The functions λ are obtained by transforming the differential equation for the potential into an integral

equation. By analogy with (5) we write for the distortion of the potential of the ionic atmosphere

$$\varphi(r,\theta) = E \sum_{r=1}^{\infty} \sum_{n=0}^{\infty} Q^r e^{2r} (\epsilon kT)^{-r} a^{1-r} \lambda_{r,n}(r) P_n(\cos\theta), \quad (6)$$

θ being the angle co-ordinate. Provided ψ_1 and φ are known, U can be calculated. Hence the problem is resolved into the determination of the functions $\lambda_{r,n}$. They are found from the equations of motion of the electrolyte and of the ions.

A serious difficulty for any theory of cataphoresis is to obtain satisfactory boundary conditions for the solid–liquid interface. We have no exact knowledge of the structure of the interface, and indeed it is from experiments like electrophoresis that we must derive information. Hence it is very desirable, if possible, to formulate basic assumptions on the surface state, in as broad a manner as possible, precluding specific mechanisms. It has been possible to derive (4) with the following simple assumptions about the interface:

(I) The thickness of the region in which the surface charge resides is small compared with the particle radius.

(II) The charge in this surface region is immobile.

(III) The surface charge density at any point is an explicit function of the ionic concentrations in the adjacent electrolyte and of the temperature only. (The surface parameters in (4) are partial derivatives of this function with respect to n_i.)

Assumption I is almost certainly true; II may be incorrect, but surface conductance is unimportant provided $\sigma_s \ll \sigma a$ (where σ_s is the surface conductance). Assumption III is more speculative but it seems very plausible; for example, in conjunction with assumption II, it would certainly be valid for a surface charge produced by adsorption of ions.

Overbeek expresses U in a series of powers of ζ (up to the third power). Using (5) to relate Q and ζ, his results should give formula (4) correct to Q^3; agreement seems fairly satisfactory although his method is rather different from ours. He employs, however, a more restrictive assumption than III above, namely, that the charge density on the surface is fixed; this cannot be strictly correct. Another basic assumption made by Henry is that the 'inertia terms' in the equations of motion of the electrolyte can be dropped. It can be shown that this is equivalent to assuming that U is proportional to the field strength E—a result often experimentally confirmed. A more exact formula for U [11], taking into account the inertia terms, is

$$U = \frac{EeQ}{6\pi\eta a} X_1(b) + \sum_{r=2}^{\infty} (EeQ)^r \eta^{-2r} [W_r(b) + O(Q)]. \quad (7)$$

The series of functions W_r, of which the first two members have been found, are, like X_r, Y_r and Z_r, very complicated. Oseen's linearized equations were used to deduce (7); in fact, the problem is closely related to a well-known problem of hydrodynamics —the determination of the drag on a sphere moving through a liquid. The most complete solution of this problem is due to Goldstein[13], and we have used his analysis extensively.

Another improvement of Henry's formula is to take into account the effect of surface conductance. For an insulating particle with a surface conductance σ_s, and with a thin double layer, we find[13] that the right-hand side of (3) should be multiplied by the factor $\sigma a(\sigma_s + \sigma a)^{-1}$, where σ is the ordinary bulk conductance of the electrolyte. The importance of the surface conductance effect evidently depends upon the relative magnitudes of σ and σ_s. Some experiments by Rutgers[14] suggest that the interface may possess very high surface conductance; hence surface conductance may be of great importance in interpreting the results of cataphoresis measurements. It is natural to inquire if a formula of type (4) might be given in this case. There are no additional mathematical difficulties, but unfortunately we require much more detailed assumptions than I–III for the conditions at the surface. For example, we should require the rate of 'condensation' of ions on to the surface and the rate of 'evaporation'.

Another problem under consideration is the determination of the rate of electrophoresis for solid particles in the form of ellipsoids. This should be of use in biological applications where spherical particles are not always available, for example, in the investigation of proteins.

We shall now consider the sedimentation potential. Smoluchowski's formula for the sedimentation potential, like his formula for electrophoresis, applies only to a *thin* double layer. I have extended this to the general case[15] by using methods similar to those for formula (4). As is to be expected, the removal of the condition $b \gg 1$ introduces a complicated function of b and of the surface parameters on the right-hand side of equation (3).

Finally, we come to the electroviscous effect. The first calculation of the effective viscosity η of a solid suspension of spheres in a liquid of viscosity η_0 was made by Einstein[16], who found

$$\eta = \eta_0 \left(1 + \frac{5}{2}\frac{v}{V}\right), \quad (8)$$

where v is the volume of solid, V of the suspension. This formula only applies for $v \ll V$. A better formula was given by Guth[17], who added the term $109v^2/14V^2$. Smoluchowski[18] in 1916 pointed out that a charge on the solid particles should increase the viscosity, and published without proof the following formula:

$$\eta = \eta_0 \left(1 + \frac{5}{2}\frac{v}{V}\left[1 + \frac{\Gamma}{\sigma\eta_0 a^2}\left(\frac{\zeta\varepsilon}{2\pi}\right)^2\right]\right). \quad (9)$$

Later, Krasny-Ergen[19] gave a proof; his equation being identical with (9) except for the multiplication of the last term by 1·5. Both formulæ only apply for a thin double layer. I have, however, succeeded in finding a formula for η, without this restriction[20]. The more general formula does not agree with equation (9), and I believe that Krasny-Ergen's treatment is incorrect. With this, we conclude our account of recent theoretical developments.

Much further work remains to be done, but at this stage it would seem that a thorough experimental check of theory would be more valuable than continued elaborations of the latter. The most useful procedure would be the determination of the electrokinetic potential ζ for a given surface and electrolyte by as many different methods as possible. The results would indicate if the theory required drastic or only minor modifications. In reading the literature, the impression is inescapable that in the past much effort has been wasted because experimentalists have confidently used formulæ without realizing their limitations, or at any rate without attempting to ascertain, so far as possible, whether basic assumptions for their validity were satisfied in their work.

Only when a theory is well tested can it be applied to new experimental data and conclusions drawn therefrom with a reasonable degree of certainty.

[1] Verwey, Philips Laboratory Research Reports, **1**, 33 (1945).
[2] "The Electrical Double-Layer: a Symposium", *Trans. Farad. Soc.*, **36**, pt. 1, 1 (1940).
[3] Hermans, *Phil. Mag.*, **26**, 674 (1938).
[4] Helmholtz, *Ann. der Phys.*, **7**, 337 (1879).
[5] Smoluchowski, "Graetz' Handbook", **2**, 374 (1921).
[6] Henry, *Proc. Roy. Soc.*, **A, 133**, 106 (1931).
[7] Hermans, *Phil. Mag.*, **26**, 650 (1938).
[8] Komagata, Researches of the Electrotechnical Laboratory of Tokyo, No. 387 (1935).
[9] Overbeek: Sonderabdruck a. d. Kolloid-Beiheften, **54**, 287 (1943).
[10–15] Booth, to be published shortly in *Proc. Roy. Soc.* and other journals.
[16] Goldstein, *Proc. Roy. Soc.*, **A, 123**, 225 (1929).
[17] Rutgers, *Trans. Farad. Soc.*, **36**, 69 (1940).
[18] Einstein, *Ann. der Phys.*, (4), **19**, 289 (1906).
[19] Guth, *Koll. Z.*, **74**, 147 (1936).
[20] Smoluchowski, *Koll. Z.*, **18**, 194 (1916).
[21] Krasny-Ergen, *Koll. Z.*, **74**, 172 (1936).

OBITUARIES

Dr. Charles Bolton, F.R.S.

THE death on December 6 of Charles Bolton, at the age of seventy-seven years, removes one more member of that distinguished band of clinicians who, during the opening years of the century, so successfully combined general consulting practice and fundamental research. The impulse to contribute to the knowledge of his subject was undoubtedly the result of his early contacts. When Bolton went to University College, London, the Medical School had not yet separated from its parent body, and the department at University College combined both clinical and pre-clinical subjects and housed all the laboratories. At that time the medical faculty comprised a galaxy of talent. Thane and Schafer were at the height of their powers, and were soon to be joined by Bayliss and Starling. On the clinical side were Ringer, Barlow, Rose Bradford, Victor Horsley and Sidney Martin. Coming into this atmosphere as he did, fresh from an apprenticeship in general practice, Bolton was, as he often told later, first astonished and bewildered, and then inspired. He never lost the scientific enthusiasm then aroused. Following medical qualification, he began investigations on the bacteriology of typhoid fever and the morbid anatomy of diphtheria. These attracted sufficient attention to gain for him, in 1903, the Grocers' Company research studentship, and so the opportunity for laboratory research. This he utilized so well that five years later he was appointed, on a part-time basis, first director of the new Graham Research Laboratories at his own Medical School. This post he held until 1914, when it was merged with the lectureship in pathology—which Bolton also held—in a single whole-time post to which the late Prof. A. E. Boycott was appointed. But Bolton continued to work part-time in the Graham Department until the outbreak of another war, in 1939, closed his Medical School and so brought to an end his researches. In the intervening quarter of a century Bolton had been a busy general consulting physician, in wide demand, and with no source of livelihood but his practice. Yet, throughout that time, at least one afternoon a week was reserved for research.

Bolton will be remembered chiefly for his work on two subjects: the formation of tissue fluids and œdema, and the production of peptic ulceration. His interest in œdema and ascites sprang directly from clinical observations and particularly those on a case of illness which, nowadays, would be diagnosed as constrictive pericarditis. At this time the teaching of his friend Ernest Starling, that the rate of formation of tissue fluid was determined by the balance of hydrostatic and osmotic pressures across the capillary membrane, was gaining acceptance. Bolton set himself to determine the factors concerned in ascites. Re-reading his work to-day, it is impressive to note how often Bolton's conclusions, once regarded as strange, have been vindicated by subsequent discoveries. By direct experiment he showed that increased venous pressure in itself could not account for the ascites, and he clearly stated: "The abnormal output of lymph leading to dropsy is primarily conditioned by the nutritive state of the capillary wall". Thirty years later, Landis reached the same conclusions from his demonstration of the deleterious effect of anoxia on capillary permeability. Again, the increased blood volume in cardiac failure had been discovered by Lorrain-Smith, and was then considered to be one of the causes of dropsy. Bolton grasped clearly that, under such abnormal conditions, fluid may be lost into one part of the body so that the remainder becomes dehydrated. He wrote: "The increase in blood volume must, therefore, be looked upon as a secondary phenomenon and due to an effort of the animal to make up its normal quantity of blood in the anæmic areas, and to replace the fluid lost as dropsy". Modern measurements of blood volume, cardiac output and tissue-fluid spaces would essentially confirm this conclusion, which seemed so strange when first enunciated.

Bolton's main contribution to our knowledge of peptic ulceration concerned the conditions necessary to produce acute ulceration. By injecting suspensions of one animal's gastric mucosa into another species, he was able to produce an anti-serum which, on intraperitoneal injection into the donor species, caused acute ulceration in the stomach. The interesting point then emerged that the gastro-toxic serum produced no visible effect on the gastric mucosa unless this were in contact with acid gastric juice. Neutralize the acid and no ulcers occurred; augment it directly, or by suitable feeding, and ulceration was increased. Clearly the gastrotoxin had produced a definite, if invisible, temporary damage to the gastric mucosa which deprived it of its natural resistance to acid. Bolton believed that such damage occurred in the course of disease, and so led to acute ulceration. With Cruveilhier he believed that chronic peptic ulcers originated as acute ulcers; but although he tried repeatedly, he could not prevent the healing of the acute ulcers he produced by gastrotoxins. By artificially delaying the emptying of the stomach, by augmenting acidity, he succeeded in delaying, but not in preventing, healing. It now seems probable that, if he had only maintained a consistent hyperacidity, he might have seen his acute ulcers become chronic. Nevertheless, he had clearly appreciated the importance of acidity in exaggerating and delaying the healing of gastric lesions; and it was on that basis that he formed his therapy of these illnesses.

Personally, Bolton was a massive Yorkshireman with a typical dry humour. He possessed a remarkable power of effortless concentration which rendered him cheerfully impervious to all distractions. Yet he was

never unapproachable, and once his attention was captured he could be most helpful. To colleagues and students alike he was uniformly genial and unaffected. Undoubtedly Bolton was fortunate in the times in which he began his professional work, for seldom can conditions have been more favourable for the combination of clinical practice and research. The solid bases of descriptive medicine and morbid anatomy had been laid, and physiology had sufficiently advanced to become applicable to clinical problems. The methods of approach and the techniques required for clinical research differed little from those used in routine practice, and the extra knowledge necessary for research, at that stage in the development of medicine, was not yet so large as to demand the whole of a man's attention and time. The business of living was also easier, and consultants could afford time for other activities than practice. Such a coincidence of conditions could only be transient, and with its disappearance the combination of private consultant and research worker began to disappear, so that now it is hard to find an example, outside certain specialties. Yet, if our medical schools are not to become simply technical institutes, if something more than technology is required in the training of a physician, then effective steps to prevent the separation of medical research and practice must be taken.

It must again be made possible for men like Bolton to devote adequate time to investigating their subjects. Undoubtedly the conditions now required will be very different from those which sufficed in the spacious Edwardian days when he flourished; but the ideal which inspired Bolton is still there, and, given the opportunity, its devotees will fulfil it.

H. P. Himsworth

Dr. Emily Berridge

Dr. Emily M. Berridge, who died on October 8, in her seventy-sixth year, has slipped away from the world of science as unobtrusively as she lived in it. But live in it she did her whole life long, devoting her life to research from her youth, when she was encouraged by her father, himself an experimenter, and by her head-mistress, Miss Arnold of the Dulwich High School, to make science her career. In 1894 she went up to the Royal Holloway College as an entrance scholar in natural science, and it was here she began research work in botany (under Prof. Margaret Benson).

Dr. Berridge's published researches fall into two distinct groups. The early papers, studies on fossil plants, and on the groups Gnetales and Amentiferæ, published mainly in the *Annals of Botany* and the *New Phytologist* between 1905 and 1914, bear the mark of her early training in Dr. Benson's special field of botany. The later papers, studies in bacteriosis published in the *Annals of Applied Biology* between 1921 and 1930, recall her colleague Dr. Paine, in whose laboratory at the Imperial College of Science and Technology, London, she worked during these years. The explanation of this complete change in type of research is to be found in her war work, 1914–19, which was done with Dr. Ernest Glynn in the Thompson Yates Laboratory, University of Liverpool, on agglutination of dysentery bacteria and the preparation of serum.

Not only did Dr. Berridge carry out research herself but she also gave generously of her time, thought and money to young postgraduates just starting on research. The extent of her generosity will never be known, for her gifts were mostly made anonymously. She was shy and diffident about her own work and so truly humble that only those who worked with her knew how good it was; just as only those who served with her on research committees knew of the quick grasp of essentials, the sound judgment and the unassailable integrity of mind and purpose that she brought to the discussion of any problem.

E. M. Blackwell

Dr. André Kling

Dr. André Kling died on August 8, 1947, at the age of seventy-five. Receiving his education and early training in Paris, he was appointed in 1911 director of its municipal laboratory. The frauds in food and wine, to restrain which the laboratory had been founded under Charles Girard, were now declining, but the First World War opened to the laboratory new fields of activity. The Explosives Service, initiated by Girard during the anarchist bomb panics, was now developed for the disposal of unexploded German missiles; and Kling's leadership was an example of personal courage no less than of professional ability. His experience and success in this field led to his appointment as scientific adviser to the French General Staff. Working in this capacity at the front line on explosives and war gases, he earned the Croix de Guerre and membership of the Legion of Honour.

After the War, Kling interested himself effectively in the internationalization of analytical methods and standards. During the nineteen-twenties he presided over the International Union of Chemistry's Commission on Pure Substances for Research, to which he presented a report which led to the inception in 1928, under his presidency, of a separate Commission of Analytical Chemistry. In France, he was a pioneer in the formation of the Société de Chimie Industrielle, in which he held office on various occasions.

In actual chemical work, the name of Kling is perhaps most readily associated with the analytical separation of the metals of Groups III and IV. He was also, however, the author of numerous papers on methods of food examination, and, outside the analytical field, on the high-temperature hydrogenation of aromatic compounds. This work, even after his official retirement, continued to the end of a life wholly dedicated to his profession.

Prof. J. Masson Gulland, F.R.S.

Dr. Jesse P. Greenstein, chief of the Biochemistry Section, U.S. Public Health Service, writes: "The loss of Prof. J. M. Gulland to the scientific world is deeply regretted by his colleagues in the United States who knew the man and admired his personality and achievements. Gulland was one of a group of distinguished foreign guests at the Cold Spring Harbor Symposium held in June 1947. He was easily the dominant figure at that conference, and the charm and ease of his manner, his gentle critical spirit, together with the scholarliness and incisiveness of his thinking, evoked general admiration and affection. Gulland's investigations in the field of the nucleic acids revealed a meticulous and sound approach, and were of great interest and still greater promise. It is indeed a sad misfortune that we should have lost him."

NEWS and VIEWS

British Association: Annual Meeting

SIR HENRY TIZARD was installed as president of the British Association at a meeting held at Burlington House on January 9, when the Committees of Sections met to draft the outlines of their programmes for the forthcoming annual meeting, to be held this year during September 8–15 at Brighton. Emphasis will be given to scientific subjects which have a bearing on the economic crisis; a preliminary programme will be issued in the beginning of April.

The officers of the Association for the present year are as follow: *President*, Sir Henry Tizard; *General Treasurer*, M. G. Bennett; *General Secretaries*, Dr. Edward Hindle and Sir Richard Southwell; *Presidents of Sections*, Sir Lawrence Bragg (Physics and Mathematics), Prof. John Read (Chemistry), Dr. A. E. Trueman (Geology), Prof. H. Graham Cannon (Zoology), Lord Rennell of Rodd (Geography), Sir Hubert D. Henderson (Economics), Wing-Comm. T. R. Cave-Browne-Cave (Engineering), R. U. Sayce (Anthropology and Archæology), Prof. H. Hartridge (Physiology), Prof. A. Rex Knight (Psychology), Prof. J. R. Matthews (Botany), W. O. Lester Smith (Education), Dr. G. Scott Robertson (Agriculture).

International Geological Congress

SIR JOHN ANDERSON has accepted the office of honorary president of the General Organising Committee for the eighteenth session of the International Geological Congress, which is to be held in Great Britain this summer, and will welcome the delegates and members at the first meeting of the General Assembly. Prof. H. H. Read, president of the Geological Society of London, has succeeded the late Sir Thomas Holland as president of the General Organising Committee and president-designate of the Congress. More than a thousand geologists from countries overseas are expected to attend the Congress; the total attendance, including British geologists, is likely to approach two thousand. Twenty-eight Governments and about 160 universities and scientific institutions have already accepted invitations to be represented by official delegates. The meetings of the Congress will be held during the period August 25–September 1 in the Royal Albert Hall and the lecture theatres of the Royal Geographical Society and the Imperial College of Science and Technology. Sir Edward Bailey and Prof. O. T. Jones will deliver special addresses on the structural history of Britain.

The list of subjects to be discussed at the sectional meetings of the Congress is as follows: (A) problems of geochemistry; (B) metasomatic processes in metamorphism; (C) rhythm in sedimentation; (D) geological results of applied geophysics; (E) geology of petroleum; (F) geology, paragenesis and reserves of the ores of lead and zinc; (G) geology of sea and ocean floors; (H) Pliocene – Pleistocene boundary; (J) faunal and floral facies and zonal correlation; (K) correlation of Continental vertebrate-bearing rocks; (L) earth movements and organic evolution; (M) other subjects. In addition, problems of African geology will be considered at open meetings of the Association des Services Geologiques Africains; and selected palæontological topics will be discussed by the International Palæontological Union. A series of meetings on the mineralogy and geology of clays will be organised in conjunction with the Clay Minerals Group of the Mineralogical Society. In addition to the thirty-two geological excursions previously announced, five more excursions are being organised; two of these will visit East Anglia, one will visit Jersey, and two others will demonstrate the general geology of Scotland, and the hydrogeology of England and Wales. There will also be a series of day and half-day geological excursions. Full details of the excursion programme and of other arrangements for the Congress can be obtained from the General Secretaries, 18th Session International Geological Congress, Geological Survey and Museum, Exhibition Road, London, S.W.7.

International Congress of Anthropological and Ethnological Sciences

THE third session of the International Congress of Anthropological and Ethnological Sciences (which met in London in 1934 and Copenhagen in 1938) is to be held under royal patronage at Brussels-Tervueren, during August 15–23, 1948. The president will be Prof. Ed. De Jonghe (University of Louvain); secretary, Prof. Frans M. Albrechts (University of Ghent, director of the Museum of the Belgian Congo); treasurer, Prof. Fr. Twiesselmann (University of Brussels, curator of the Royal Museum of Natural History). The subscription for full members is £2 2s.; for associates 200 Belgian francs. The Congress will meet in twenty-four sections, covering all branches of anthropological and ethnological research. Communications must be sent in typewritten synopsis, of not more than 200 words, to the Secretary before June 1; the full text and illustrations before July 1. Provision will be made for films and sound-records. There will be several exhibitions in connexion with the Congress; and excursions during August 24–28. Accommodation may be reserved either in the 'Cité Estudiantine' of the University of Brussels at 165 Belgian francs a day; or in hotels through Wagon-Lits-Cook, 17 Place de Brouckère, Brussels; approximate cost, room 100–200 Belgian francs; meals, 75–125 Belgian francs. Formal dress will not be required for any of the functions. The Organising Committee will endeavour to obtain currency facilities and reduced fares. Correspondence should be addressed to the Secretary, Musée du Congo Belge, Tervueren.

Embryology of Monsters

A RECENT issue of *Ciba Symposia*, a journal produced by a pharmaceutical firm, contains two informative articles on monstrosities in embryological development. The first, by Dr. Hamburger, professor of zoology in Washington University, St. Louis, is a general account of natural and experimentally induced maldevelopments. The second, by Dr. Wolfgang Born, of the Department of Fine Arts of Louisiana State University, traces the course of monstrosities, real and imaginary, as they appear in painting, sculpture and mythology. It is interesting that Dr. Born is a son of the Gustav Born who was one of the founders of experimental embryology, and one of whose main discoveries was that two halves of a divided amphibian embryo will fuse together if they are kept in apposition. It is widely believed that this finding was one of those brilliant outcomes of an accidental observation. In the course of Born's studies on regeneration, some tadpoles were halved just after hatching. To enable him to distinguish individual larvæ on which he was working, he left a part of the skin of the back intact after

having halved the bodies. To his surprise he found next day that the halved larval bodies the dorsal skin of which had been left intact had re-united and healed together.

This observation led Born to the fundamental discovery that it is possible to join together as a chimæra the half of an embryo of one amphibian species with that of another. This fact provides the basis for the many transplantation and grafting experiments out of which much of experimental embryology as we know it to-day has developed. The centenary of Gustav Born's birth takes place in 1951, and it is to be hoped that the occasion will be properly celebrated by the publication of a commemorative volume tracing the story of his work and its subsequent development. The present issue of *Ciba Symposia* is a reminder of his very great contributions to experimental embryology, and of the widespread interest which the subject of monstrosities has always aroused.

Simultaneous Recording of Related Oscillograph Traces

DURING the War, the frequent need in such fields as ballistics, and the study of mechanical shock and vibration, to obtain information about the temporal variation of quantities, and in particular the interrelationship of these variations, led to a considerable use of the cathode ray oscillograph and moving-film technique. The methods of obtaining several records at once so as to permit a study of this interrelationship included the use of double-beam oscilloscopes, electronic switches for beam splitting, ganged cameras, and the photographing of a number of screens on the same film. Messrs. Cossor designed a unit comprising a 70-mm. film camera facing the screens of two double-beam tubes, and provision was made for ganging three such instruments together. The problem became more difficult, however, when it was desired to record some fifteen traces on the same film, as it was obviously impracticable to photograph fifteen oscilloscopes in line and still retain reasonable trace amplitude. To meet such a requirement, Messrs. Avimo Ltd., Taunton, have produced a series of units, employing up to fifteen $1\frac{1}{2}$-in. cathode ray tubes photographed through mirrors on 70-mm. film or paper. The apparatus is robust and portable, and has a range of film speeds of 1–50 in./sec. The optical reduction factor is 2·5, and a microscope is provided to allow observation of the traces during recording. Of particular importance is the provision of adjustments to permit the alignment of the tubes so that each deflexion shall be normal to the film motion and all the deflexions shall be colinear.

Rubber Developments

Rubber Developments is a new illustrated quarterly, issued gratis by the British Rubber Development Board, Market Buildings, Mark Lane, London, E.C.3. The primary purpose of the journal is to direct attention to fresh or extended applications of the use of rubber, and it is addressed more to the potential user than to the manufacturer of rubber. The first number, consisting of 40 pages, contains articles on the rehabilitation of rubber estates in Malaya, liquid latex, engineering with rubber, and 'Positex', as well as other features. It is interesting to note that there are now six pamphlets available describing 'Positex' and its applications to woollens, cotton, linen and other yarns, and felts, and also its use as a textile printing paste. The British Rubber Development Board is a non-profit-making organisation, deriving its funds from a cess on raw rubber exported from the British production areas. The Board works in association with corresponding units in France and Holland, the work being co-ordinated on an international basis by the International Rubber Development Committee, the area allocated to the British Board comprising the British Empire and the United States.

Unasylva: A Forestry and Forest Products Review

THE first number of *Unasylva*, a new, illustrated, bi-monthly magazine of forestry and forest products, published by the Food and Agriculture Organisation of the United Nations, is dated July–August, 1947. Editions are being issued both in English and French, and a Spanish edition is planned for the near future. The aim of the journal is to shed light on all problems connected with forestry, to compare the methods used in different countries and to present the opinions of experts in the various fields. It is realized that the nations working together through the Food and Agriculture Organisation cannot hope to achieve their main objectives if due regard is not paid to the vast forests of the world. Conservation of those that perform useful social or protective functions is essential; their soils must be used wisely if productivity is to be maintained, and improved methods of processing and utilizing forest products need to be found. In the first number, Sir John Boyd Orr, director-general of the Organisation, contributes a foreword, while articles relating to the disappearance of the tropical forests of Africa, forest utilization, and the growth of the world's forests appear under the subheading "Problems". In the section dealing with "National Situations" are papers on timber shortage or timber abundance in the United States, and forest and forest products research in Canada, while a further part is devoted to a description of the scope and framework of the Forestry Division of the Food and Agriculture Organisation. Distributing agents for the new magazine are being selected for various countries and areas. Meanwhile, orders are being taken by the Documents Office, FAO, 2000 Massachusetts Avenue, N.W., Washington 6, D.C., U.S.A.

Physical Chemistry at the Mellon Institute

A DEPARTMENT of Research in Physical Chemistry has been established at the Mellon Institute of Industrial Research, University of Pittsburgh, to conduct fundamental investigations in its domain for professional and public benefit. Since its beginning, the Mellon Institute has recognized the need of fundamental scientific research as a background and source of stimulus for investigations in applied science. The Institute has therefore supported extensively disinterested investigations planned within the organisation and focused on the study of more basic problems than those usually pursued in researches in applied science or technology. This new Department of Research in Physical Chemistry will supplement the Institute's work in pure science, carried on since 1911 and formally organised under the Department of Research in Pure Chemistry in 1926 and the Department of Research in Chemical Physics in 1946. The Department of Research in Pure Chemistry specializes in the organic, biological and pharmaceutical fields. As investigations in pure science are completed, the results are published and widely disseminated. Dr. John R. Bowman, who

has been appointed head of the Department of Research in Physical Chemistry, has distinguished himself in applied mathematics, particularly as employed in the analysis of chemical engineering problems, and in petroleum chemistry, especially in his comprehensive original work on distillation. He was born in New York, in 1910, and educated at the University of Pittsburgh and at the California Institute of Technology. Since 1935 he has been at the Mellon Institute, on the multiple fellowship of the Gulf Research and Development Co.

Public Libraries in Germany

H. SCHURER's paper "Public Libraries in Germany", published as No. 5 in the German Educational Reconstruction Series (15 James Street, London, W.C.2), gives a readable account of the development of the public library system in Germany and of the two schools of thought, neither favouring open access to the shelves, which influenced that development down to the Nazi regime; it also deals with the part which the system could play in the educational reconstruction of Germany. The ideas of Walter Hofmann and his school in making book selection the decisive intellectual task of library service, with all its implied demands on the library staff, are set forth in some detail and should be of considerable interest to those engaged in library work in Britain, whether in the public library service, in the universities or in industry and commerce. The special characteristics of the tradition of German librarianship are of international significance, and a chapter in L. R. Wilson and M. F. Tauber's book on the university library suggests that that tradition has already made its influence felt in the United States as a positive contribution in library service. As regards the immediate future in Germany, apart from the restoration of damaged buildings and the recovery of lost stocks, Mr. Schurer considers that the main task will be the negative one of undoing most of the work of the Nazis, including the elimination of Nazi literature from book collections, removal of ardent Nazis from responsible positions, the preparation of new readers' guides and the training of library workers. Furthermore, he considers that the principle of open access must now be adopted, and he looks to a steady increase in the number of readers and to a healthy development of local and regional efforts rather than national or centralized efforts.

Glasgow Art Gallery and Museum

COMMENDABLE enterprise in making the natural history department attractive to visitors has been shown recently by the Glasgow Art Gallery and Museum. Despite special difficulties caused by enemy action during the War, considerable material has been salvaged and displayed as a series of habitat groups in an Animal Court at the Museum. The first and second arches contain representative samples of African and Indian animals, and the others in preparation will display animals of Australia and the Scottish Highlands. To accompany each display the Museum is publishing a series of attractive booklets in which each animal typified is described and illustrated. "Animals of Africa" and "Animals of India" are already available.

Medical Sub-Section of the Library Association

THE first ordinary meeting of the newly formed Medical Sub-Section of the Library Association was held at the National Institute for Medical Research on January 2. In welcoming the seventy or more members and guests, Dr. C. R. Harington, director of the Institute, spoke of the increasingly important part played by library services in the modern medical world and of the invaluable aid that specially trained librarians could give to those engaged in medical practice and research. Dr. G. Popjak gave an illuminating talk on recent developments in nuclear physics and their medical applications; his exposition of the manufacture of radioactive isotopes was much appreciated. Miss Ethel Wigmore, librarian to the Medical Research Council and a member of the Committee of the Medical Sub-Section, then described the work of the Library of the Institute, and this was followed by a conducted tour. The members were especially interested in the system of indexing current periodical literature pending the issue of the *Quarterly Cumulative Index Medicus*, and in the very comprehensive subject-index to the large collection of reprints.

Institution of Electrical Engineers: Awards

THE triennial award of the Coopers Hill War Memorial Prize and Medal, which fell in 1946 to the Institution of Electrical Engineers, has been made by the Council to Mr. E. C. Cherry, for his paper on "Analogies between the Vibration of Elastic Membranes and Electro-Magnetic Fields in Guides and Cavities".

No award having been made in 1946 of the Page Prize for the best thesis in lieu of the Associate Membership Examination of the Institution, the Council has awarded two Page Prizes for 1947: one to Mr. D. T. Hollingsworth for his thesis entitled "An Account of the Development of the Accessories for a Cable with the Dielectric under Pressure"; and the other to Mr. M. K. Taylor for his thesis entitled "The Transmission of Voice Frequencies by Height Modulated Pulses of Constant Recurrence".

Announcements

APPLICATIONS are invited for research fellowships, normally of the value of £600 per annum, founded by Imperial Chemical Industries, Ltd., tenable in the University of Cambridge and available for research in physics, chemistry, biochemistry, engineering, metallurgy, pharmacology, chemotherapy, or related subjects. Applications should be received not later than April 30. Regulations governing the award of the Fellowships may be obtained from the Secretary of the Board of Research Studies, The Old Schools, Cambridge, to whom all applications should be addressed.

A PRELIMINARY announcement under the title "Photostat Copies of German Scientific and Technical Papers" appeared in *Nature* of September 27, 1947, p. 427. It has now proved possible to reduce the cost of this service and a revised charge of 6*d*. per page, irrespective of number, is now being made.

ERRATUM.—Mr. A. B. Wardrop and Dr. R. D. Preston write: "In our recent article entitled "Organisation of the Cell Walls of Tracheids and Wood Fibres" in *Nature* of December 27, p. 911, we inadvertently allowed the same mistake to occur in three places. The legends to the abscisse of Figs. 3 and 4 should read 'Angle of section to *transverse* plane' and the word 'increasing' (p. 912, line 8) should read 'decreasing'."

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Audio-Frequency Radio Waves from the Sun

THE recent discovery of solar radio noise, in the range 30–1,000 megacycles, raises the question whether lower frequencies may not also exist. Variable magnetic fields exist on the sun and probably in the stars as well. Small and rapid pulsations of spot fields may well occur, even though detection of the variations, by studies of the Zeeman effect, will prove difficult. Nevertheless, we may expect that these changing fields will produce electromagnetic radiations the maximum wave-lengths of which are comparable to stellar dimensions. Such low-frequency radiation will escape from the sun in the presence of a steady magnetic field, like those found in sunspots.

Partial absorption of such waves in the solar atmosphere may produce the observed high excitation of chromosphere, prominences and corona. In the earth's atmosphere, similar absorption may be responsible for the luminosity of the night sky and, possibly, also for the aurora polaris. The concentration of the latter in a zone near the magnetic poles may arise from the tendency of accelerated ions to spiral around the lines of magnetic force.

To explain the observed terrestrial effects as the action of solar electromagnetic waves, we require voltages of the order of 0·01–1·00 volts per cm. We postulate the existence of frequencies in the range of from 1 to, say, 500 cycles per sec., though the extent of the range is unimportant for our argument. These long waves will be diffracted around the earth and hence may well cause effects on the dark, as well as on the sunlit, hemisphere. With these assumptions, one readily calculates that an amplitude of at most several gauss, with the appropriate frequency, in the field of a spot can produce the desired radiation.

The total energies involved in the radiation are roughly equivalent to that from an area of normal photosphere about equal to that of a spot. Hence, we further suggest that the emission of radio energy provides a simple mechanism for cooling the spot.

The long-wave emission may account for many ionospheric phenomena, such as sporadic *E*. The waves will cause any 'seed' ionization to spread—a sort of multiplier effect. Some phases of ionospheric storms may also be explained as due to heating of the layers by the absorbed radiation. The waves will have a similar action on meteor trails, the growth and persistence of which are difficult to explain in terms of the meteor itself. The voltages and wave-lengths are sufficient to produce, in regions of low density, high-energy particles, like the softer components of cosmic rays. We suggest that the phenomenon here discussed may be the source of cosmic rays. We suppose that the harder components arise in stars the magnetic variations of which are much more intense than for the sun.

The suggestions made above demand experimental verification. As a first step in the study, we have constructed a large loop antenna, connected to a tunable audio amplifier. With this device, we have detected the existence of variations of the order of magnitude herein suggested, and of frequencies from 25 cycles (the lowest limit of the amplifier) to about 400 cycles.

Further experiments are in progress to determine whether we can attribute the effects to electromagnetic waves of solar origin, or whether we must assign them to micropulsations of the earth's magnetic field.

DONALD H. MENZEL

Harvard Observatory,
Cambridge, 38, Mass.

WINFIELD W. SALISBURY

Collins Radio Company,
Cedar Rapids, Iowa.

Showers of Penetrating Particles

THE intensity of several 'components' of the cosmic radiation varies with atmospheric depth more rapidly than the intensity of the so-called total radiation (curves of Pfotzer and Millican): for example, showers of penetrating particles measured with a counter arrangement vary according to an exponential law $e^{-x/d}$, where x is the atmospheric depth in gm./cm.^{2} and $d \sim 100$ gm./cm.^{2} [1]. The cross-section for the collision of a primary shower-producing particle with a nucleus in air is of the order $2{\cdot}5 \times 10^{-25}$ cm.^{2}. Neutrons, protons, multiple nuclear disintegrations, large bursts and slow mesons show similar rapid decrease with increasing depth.

The present remarks will chiefly refer to the showers of penetrating particles. Some of them contain at least four particles each penetrating 20 cm. lead, as we have observed by means of eight-fold coincidences between eight counters arranged in four telescopes scattered on an area of 4 m.^{2}. Each counter was surrounded on all sides by 10 cm. lead. The frequency of these showers in S. Paulo (altitude 800 m.) was 3×10^{-4} min.$^{-1}$. Examination of experimental data on the density of particles in such showers, the existence of penetrating particles in extensive showers and the variation of meson intensity and spectral distribution at high altitudes (and at great depths) leads us to the following conclusions: the majority of mesons are produced in groups (in collisions of primary protons or secondary protons and neutrons with nuclei), with a multiplicity increasing with energy in accordance with the scheme suggested by us earlier[2].

Here we limit ourselves to the discussion of one argument. There is a striking difference between the slow variation with atmospheric depth of the frequency of single penetrating particles (chiefly mesons) as measured by a telescope (curves of Schein, Jesse, Wollan and of Ehmert), and the rapid exponential variation with depth of the frequency of penetrating showers measured by us[1]. Obviously, a telescope indicates the arrival of every meson the trajectory of which lies inside the solid angle defined by the counters. The collision process which gives rise to these mesons can take place at great altitudes above the telescope (for example, at 20 km. above), provided their life-time is long enough and their energy is not too low. Thus the telescope measures the integral intensity of mesons produced inside the solid angle defined by the telescope, whereas the large-angle arrangement of 4-fold or 8-fold coincidences used by us can only register bunches of particles created locally at distances of not more than a few hundred metres above the arrangement. Indeed, if, for example, the centre of the shower is located at 10 km. height above the arrangement, the angular spread of

the penetrating particles will give rise to an average distance between the points of arrival of two mesons on a horizontal plane (at 10 km. below the centre) greater than the distance between the telescopes of our arrangement, and no coincidence will be registered. Thus the exponential variation with atmospheric depth in our experience refers to penetrating showers produced locally.

The rapid increase of the number of slow mesons and neutrons with altitude leads us to associate these particles with local penetrating showers of low energy. The high-energy, long-lived mesons, observed at sea-level and underground, are probably produced also in groups, giving rise to extensive penetrating showers. The cross-section for these processes must be of the same order of magnitude or even greater than the value found by us for local penetrating showers. In all these collisions, energetic secondary nucleons can arise and thus the formation of cascades of nucleons and mesons must be expected.

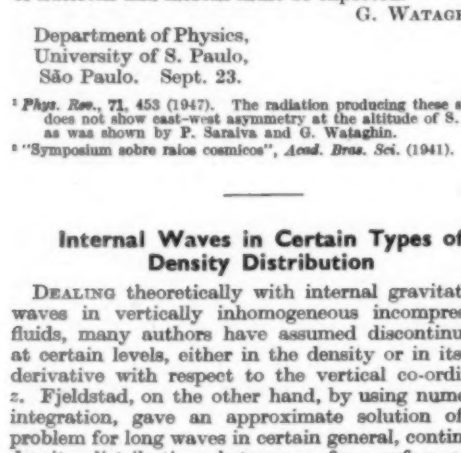
G. WATAGHIN

Department of Physics,
University of S. Paulo,
São Paulo. Sept. 23.

[1] *Phys. Rev.*, **71**, 453 (1947). The radiation producing these showers does not show east-west asymmetry at the altitude of S. Paulo, as was shown by P. Saraiva and G. Wataghin.
[2] "Symposium sobre raios cosmicos", *Acad. Bras. Sci.* (1941).

Internal Waves in Certain Types of Density Distribution

DEALING theoretically with internal gravitational waves in vertically inhomogeneous incompressible fluids, many authors have assumed discontinuities, at certain levels, either in the density or in its first derivative with respect to the vertical co-ordinate, z. Fjeldstad, on the other hand, by using numerical integration, gave an approximate solution of the problem for long waves in certain general, continuous density distributions between a free surface and a rigid bottom.



DENSITY DISTRIBUTION REPRESENTED BY A GRAPH OF THE SPECIFIC VOLUME S (THE ABSCISSA) AGAINST THE VERTICAL CO-ORDINATE z (THE ORDINATE)

It has now proved possible to deal with certain continuous density distributions analytically and find complete solutions which are not restricted to the longer wave-lengths.

The density distribution is of the general type shown in the accompanying graph; the relative variation of density is supposed to be small. The fluid is supposed to be incompressible and to be at rest in the non-perturbed state, whereas, in the perturbed state, an internal wave is propagated in the x-direction.

The perturbation is supposed to be small. If we describe the simple harmonic wave motion by means of a stream function

$$\varphi(x,z,t) = \varphi(z) \exp i(mx - nt),$$

it appears that $\varphi(z)$ may be found with, in general, sufficient accuracy as a solution of the equation

$$\frac{d^2\varphi}{dz^2} + \left(\frac{gdS/dz}{c^2 S_0} - m^2\right)\varphi = 0, \qquad (1)$$

where $S(z)$ is the specific volume in the unperturbed state, S_0 is the mean specific volume, $c = n/m =$ velocity of propagation.

As an analytical representation of $S(z)$ we have chosen $S = S_0 + \frac{1}{2}\Delta S \tanh(2z/b)$, where ΔS is the total variation of the specific volume, b is the thickness of the transition layer (see graph). The differential equation (1) then becomes

$$\frac{d^2\varphi}{dz^2} + \left(\frac{g\,\Delta S}{bc^2 S_0 (\cosh(2z/b))^2} - m^2\right)\varphi = 0. \qquad (2)$$

If the fluid extends to infinity both upwards and downwards, we have as boundary conditions, that φ must remain finite or become zero, when $z \to \pm\infty$. This is an eigen-value problem.

The differential equation (2) can be solved by means of certain transformations, the solutions being expressed in terms of hypergeometric series. The eigen-values of m, in terms of c, are given by

$$bm = \sqrt{1 + \frac{bg\,\Delta S}{c^2 S_0}} - (2k+1), \quad k = 0, 1, 2, 3, 4 \ldots,$$

etc., m being positive.

This yields relations between the wave-length $L = 2\pi\lambda$ and the period $T = 2\pi\tau$, which may conveniently be described by

$$\frac{g\,\Delta S}{b\,S_0}\tau^2 = k(k+1)\left(\frac{2\lambda}{b}\right)^2 + (2k+1)\left(\frac{2\lambda}{b}\right) + 1.$$

When $\lambda \to 0$, the period approaches a minimum value for all modes (namely, for all values of k):

$$T_{\min} = 2\pi\sqrt{\frac{bS_0}{g\,\Delta S}} = 2\pi\sqrt{\frac{S_0}{g(dS/dz)_{\max}}}.$$

It appears that any solution $\varphi_k(z)$ has k zeros for finite values of z; for $z \to \pm\infty$ it tends to zero exponentially.

It is easy to extend the theory to the case of a rotating fluid (the atmosphere or the ocean on the rotating earth). In this case, the same relation as exists between τ and λ in the previous (non-rotating) case now exists between τ and $\lambda\sqrt{1 - (2\omega_z\tau)^2}$, ω_z being the angular velocity of rotation around the vertical axis.

Further details will be given shortly in a paper by the author in the *Mededelingen en Verhandelingen van het Koninklijk Nederlands Meteorologisch Instituut*, de Bilt, Netherlands.

P. GROEN

Koninklijk Nederlands Meteorologisch Instituut,
de Bilt. Sept. 4.

Electronic Waves and Thibaud's 'Particles'

An inadvertent omission from my earlier communication[1] of the universal constant $(-e/c)$, which should multiply the right of equation (5), and, therefore, both sides of equations (11) and (12), involves that the predicted rate of energy loss by electronic wave radiation is now some 14·4 times as large. Writing $v_r = v \cos\theta$, the corrected formula (12) now reads

$$(-ec)\,\frac{\overline{A_r}}{r} = \frac{e^4}{2mc^3}\cdot\frac{v\cos\theta}{r^3}\cdot\psi\psi^* \doteq$$

$$(3{\cdot}24)10^{-31}\,\frac{v\cos\theta}{r^3}\cdot\psi\psi^* \quad . \quad . \quad . \quad (12a)$$

The radiation is now seen to depend on an even power of the charge, and so can be of negative sign only for values of θ which make $\cos\theta$ negative. An element of an electron beam is seen to radiate nothing in its equatorial plane, a maximum in the forward direction, and a negative maximum in the backward direction.

This fact, coupled with the smallness of the numeric in (12*a*), suggests the conclusion that electrons accompanied by the assumed spherical electronic waves (of low and substantially uniform group velocity) would not lose observable energy in transit. Indeed, integration of (12*a*) over all possible values of θ gives zero for a cylindrical beam, neglecting complications due to the effects of beam-forming or beam-receiving electrodes. For an expanding beam a small net rate of loss, and for a converging beam a small net rate of absorption of energy are predicted; but for electrons and all heavier particles the effect is negligible, frequently even when the restriction to nearly uniform motion is waived.

If, however, extremely light particles should come in for consideration, these conclusions might well be reversed in respect of such particles. In this connexion we must give careful attention to the beautiful researches of Jean Thibaud[2], in which he seems to establish the mass of the neutrino at $10^{-11}\,m_0$, where m_0 is the rest mass of an electron. In addition, the neutrino is, according to Thibaud, endowed with a charge, small compared with that of an electron. The term 'electrino' is suggested to cover the particle; but since Thibaud finds both positive and negative neutrinos, we should obviously need 'positrinos' as well. From the preliminary values quoted, it would appear that the radiation-rate divided by the kinetic energy of Thibaud's particles may be up to ten thousand times the corresponding ratio for electrons. For such particles moving in a non-uniform electric field, it is conceivable that this brings the radiation loss to an observable order of magnitude.

At all events, Thibaud[2] finds his particles are liable to gain or lose energy when traversing zones of intense gradient: ". . . the particle appears to suffer appreciable loss of energy per unit length of path—loss due doubtless to a radiation which is no longer negligible as for an electron".

W. E. Benham

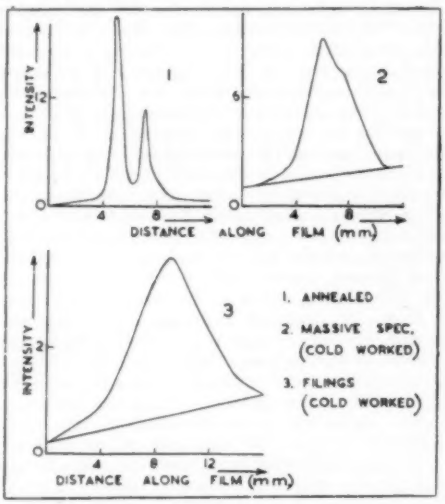
17 Sandyford Place,
Glasgow, C.3.
Oct. 4.

[1] *Nature*, **160**, 160 (1947).
[2] *C.R. Acad. Sci. Paris*, **224**, 739 (1947) (*et aliunde*).

X-Ray Diffraction Rings from Deformed Solid Metal and Metal Powders

The changes in crystalline texture of metals subjected to plastic deformation can be studied by following the increase in diffusion of the X-ray reflexions from the atomic planes. The correct procedure should be always to obtain the reflexions direct from the metal in the normal solid state. But for convenience much work has been based on the circular camera technique, where the test specimen has to be in the form of powder. The metal has been reduced to powder by filing, and measurements made of the breadth and intensity of the X-ray reflexions from the filings. These values have been compared with the breadth and intensity of the reflexions after the filings have been annealed and the effect of deformation thereby removed. The difference has been taken to represent the effect of the cold plastic deformation produced by the action of filing. Then it has been assumed that the same differences would exist between the annealed and plastically deformed state in the solid metal; also that the theoretical conclusions would be applicable directly to interpretation of the structural changes produced by plastic deformation of the solid metal.

We have considered it worth while examining these assumptions by experiment. The results are interesting and may serve to direct attention to a factor which does not appear to have been recognized in previous work.



We have compared the diffraction rings from solid metal, in the form of flat tensile specimens of iron, with the diffraction rings of filings taken from the same specimens. The tensile specimens were plastically deformed by stretching to increasing extents in order that a measurement might be made of the characteristic maximum diffraction broadening which, it has been shown, is reached after progressive deformation, and which has a specific value for a particular metal[1]. This maximum line-broadening was then compared with the breadth of the diffraction rings from the filings. For this purpose the filings were formed into a flat layer of powder, so that they might be examined by X-rays under exactly the same conditions as the flat tensile specimens.

The tests showed that the diffraction rings from the filings in all cases were broader to a striking extent than the maximum broadening obtained from the deformed solid specimens. The effect is illustrated by the accompanying microphotometer traces, obtained by traversing the typical (310) diffraction ring given by cobalt $K\alpha$ radiation. Fig. 1 is from the annealed strain-free metal, and shows the sharply resolved α_1- and α_2-components of the diffraction ring. Fig. 2 shows the broadening of the ring when a tensile specimen is extended by the amount giving the maximum diffusion; at this stage the α_1- and α_2-components are just discernible in the original photograph. Fig. 3 shows the much broader ring obtained from filings; the α_1- and α_2-components have diffused into a single halo, and, in fact, measurements indicated that the line-width was approximately twice the maximum obtainable from the solid metal. The filings referred to in Fig. 3 were taken from an annealed test specimen and represent the least deformation introduced by the action of filing. Filings taken from the plastically deformed specimens tended to give rings which were even broader. The above comparison proves, therefore, that the physical condition of the filings cannot be taken as representative of the condition of the plastically deformed solid metal, as it has been in the past.

We think the explanation will follow from recent observations on the stress-strain curves for the atomic lattice. This work, carried out on metals in the normal solid state, has shown that homogeneous plastic deformation leaves the iron lattice with permanent strains which are directional[1]. Thus after a tensile test-piece has been extended in tension the lattice spacings perpendicular to the axis remain with a residual compression, while spacings parallel to the axis exhibit an expansion, and spacings at intermediate inclinations vary in a regular manner between the two extremes. The diameter of a diffraction ring from such a specimen, since diameter depends on spacing, varies according to the angle between the reflecting planes and the axis of the specimen. This variation does not affect the inherent diffusion of the diffraction ring, because only one direction relative to the axis is photographed at one time; thus the ring can have an enlarged diameter or a contracted diameter, but not a range of diameters. If, however, the metal is reduced to filings, then the lattice expansions and contractions will be oriented at random in the powder. The diffraction ring in a photograph from the filings will be the resultant of rings varying in diameter between the extremes which correspond to the most expanded and most contracted values. Therefore the ring will possess an abnormal and adventitious diffusion in which the inherent broadening characteristic of deformation of the solid metal will be lost.

This view could be tested by measurements of the mean diameter of the diffraction rings from the solid specimen and from the filings. The broad back-reflexion ring from a stretched tensile test-piece photographed with the incident X-ray beam at right angles to the specimen showed an increase over the same ring from the undeformed material; this corresponded to a directional increase in the lattice spacing parallel to the axis, which would be expected from the above-mentioned work. The broader ring from the deformed filings, however, showed no change compared with the annealed material. This confirmed the view that the deformed filings contained a mixture of tensions and compressions oriented at random in a manner which is foreign to the deformed metal in the solid state.

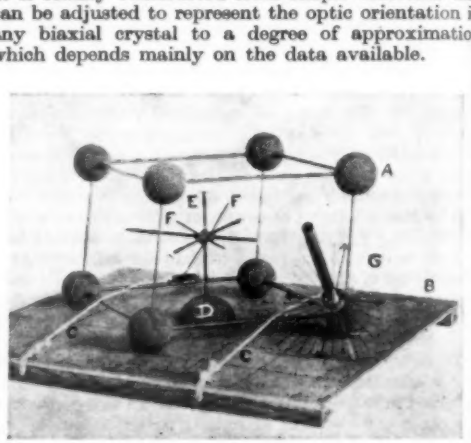
W. A. Wood
W. A. Rachinger

Baillieu Laboratory,
University of Melbourne.

[1] Wood, W. A., *Proc. Roy. Soc.*, A, **172**, 231 (1939).
[2] Wood, W. A., and Smith, S. L., *Proc. Roy. Soc.*, A, **182**, 404 (1944).

A Simple Universal Model for Representing the Optic Orientation of Biaxial Crystals

In dealing with crystals of low symmetry, a model showing the orientation of the indicatrix axes with respect to the external form helps greatly in visualizing the optical characters which will be presented by sections parallel to different faces. I have found the model described below extremely useful for this purpose, both in the study of new material and as an aid to the appreciation of published optical data. It is readily constructed from simple materials and can be adjusted to represent the optic orientation in any biaxial crystal to a degree of approximation which depends mainly on the data available.



The external form of the crystal is represented by the framework *A* (see figure), which is built up from cork balls and finely pointed brass rods, the correct angles being secured by comparison against paper templates. It usually suffices to show only the principal faces developed, for it is the sections parallel to these faces which are likely to be of most interest. The approximate inclination of secondary faces with respect to the indicatrix axes can be judged by holding a sheet of mica against the framework in the appropriate position. Only a few sets of rods are needed to build up a wide variety of models, convenient lengths being 4, 6, 8 and 10 in. The framework is secured by spring-tensioned cords *C* to the plywood baseboard *B*, in the centre of which is glued one half of a large cork ball *D*, serving as support for the indicatrix axes *E*. Each axis carries at one end a small disk marked with the appropriate symbol, while the other end is prolonged and finely pointed. By thrusting one or other of these pointed ends into *D*, the axes can be erected in any orientation with respect to the framework *A*. Two thin wires *F*, pivoted on β, represent the optic axes and can be set at any angle.

The case shown in the figure is that of the monoclinic $K_2SO_4.MgSO_4.6H_2O$ with {001} and {110},

and will serve to illustrate the use of the model. The axial plane is (010), $2V$ is 48° (+), and X is almost normal to (001), so that sections parallel to this face give a nearly centred obtuse bisectrix figure, as is immediately apparent from the model. The emergence of the optic axes, and thus the type of interference figure, on a {110} face may be made out very clearly by shifting the framework (while preserving the correct orientation with the aid of the squares marked on the baseboard) so that the axes project through the face. The extinction directions on the face may be determined by means of the sighting protractor G. This consists of a thin glass plate marked with two double arrows at right angles, and thinner radial lines at intervals of 10°. At the centre of the plate and at right angles to it is cemented a short length of thin brass tubing. The model is supported on the floor by means of a stand and clamp, with the face in question horizontal and uppermost. A thick sheet of mica is laid across the face, and on top of this is placed the protractor, which is then moved until, on looking from above, the origin of the indicatrix axes is seen to be in line with the axis of the brass tube and the double arrows bisect the projected angles between the optic axes. By the law of Biot and Fresnel the arrows then represent the extinction directions on the face. With a carefully constructed model this method gives the correct extinction angle to within about 5°. A rougher but more convenient method is simply to view the optic axes through the face, along a direction normal to it as nearly as can be judged, and find the positions at which a rod laid across the face bisects the projected angles between these axes.

N. H. Hartshorne

Department of Chemistry,
University College, Swansea.
Sept. 29.

Mode of Action of Acridine Antibacterials

Two years ago, it was shown[1] that, in a series of 107 acridines, marked antibacterial activity was, for the most part, confined to those substances which exist mainly in the form of cation at *p*H 7·3. Apparent exceptions to this rule have since been examined more closely and some important gaps in the series closed.

1-Hydroxyacridine, which possesses antibacterial activity greatly in excess of what could be predicted from its feeble ionization, has been shown to owe this biological effect to an entirely different chemical property, namely, to its ability to combine with metabolically important trace metals. This has opened up a fruitful field of investigation, with the result that antibacterial properties ascribable to this metal-chelating effect have been demonstrated in several other heterocyclic series that bear a hydroxyl-group *ana* to a ring-nitrogen[2].

The enhanced activity of 5-amino-1-hydroxyacridine is a further example of this phenomenon, but two of its isomerides seemed to form exceptions to the cationic rule. Using an approximate correction to derive the pK_a value in water from the pK_a value as determined in 50 per cent alcohol, it appeared that 5-amino-2-(and -3-)hydroxyacridines were sufficiently well ionized (71 and 98 per cent respectively) to command a greater antibacterial activity than was actually found. Re-examination of all four hydroxy derivatives of 5-aminoacridine has shown, rather surprisingly, that they produce a high proportion of zwitterions at *p*H 7·3, an effect not previously reported for simple phenolic amines. The use of a Hilger absorptiometer has permitted determination of the pK_a values directly in water[3], thus dispensing with the correction which is inapplicable when zwitterionic species are present. The corrected figures are given in the accompanying table (Nos. 22–25; the numbering of the previous paper[1] is retained for ease of reference). It is seen that the new values fall into line with those obtained from the other acridines and add further support to the correlations already found.

The synthesis of 1 : 5- and 4 : 5-diaminoacridines (Nos. 2*a* and 4*a*) completes the set of amino-derivatives of the important antibacterial, 5-aminoacridine. These showed antibacterial activity of the intensity expected from their high degree of ionization.

The inclusion of 2-dimethylaminoacridine (47*a*) provides the first tertiary mono-aminoacridine for the series. The lowered response to Gram-negative organisms (compared with the corresponding primary amine) forms the third example of such an effect in this series (the others being 2 : 8-*bis*dimethylaminoacridine and 2-dimethylamino-7-aminoacridine). This suggests that hydrogen bonding may make a contribution to the action of the primary amines on these bacteria.

No.	-acridine	Highest dilution completely inhibiting growth after 48 hr. at 37° C. (Medium : 10 per cent serum broth, *p*H 7·3)					Sum of inhibitory indices	pK_a in water at 20° C.	Per cent ionized as cation at *p*H 7·3
		Cl. welchii	*Strept. pyog.*	*Staph. aur.*	*B. coli*	*Proteus*			
2*a*	1 : 5-Diamino-	5	5	4	4	4	22	9·3	99
4*a*	4 : 5-Diamino-	5	5	3	3	2	18	11·0	100
22	5-Amino-1-hydroxy-	5	5	3	3	3	19	7·1	39
23	5-Amino-2-hydroxy-	2	4	0	0	0	6	6·6	17
24	5-Amino-3-hydroxy-	4	6	2	0	0	12	7·7	72
25	5-Amino-4-hydroxy-	3	3	1	0	0	7	5·6	2
47*a*	2-Dimethyl-amino-	5	5	3	2	0	15	8·3	91

Key to dilutions : 0 signifies growth at 1 : 5,000 ; 1 signifies inhibition at 1 : 5,000 ; 2 signifies inhibition at 1 : 10,000 ; 3 signifies inhibition at 1 : 20,000 ; 4 signifies inhibition at 1 : 40,000 ; 5 signifies inhibition at 1 : 80,000 ; 6 signifies inhibition at 1 : 160,000.

We thank Prof. S. D. Rubbo for the bacteriological testing and Mr. J. N. Phillips for experimental assistance.

Adrien Albert
Reginald Goldacre

University of Sydney.
Sept. 26.

[1] Albert, Rubbo, Goldacre, Davey and Stone, *Brit. J. Exp. Path.*, **26**, 160 (1945).
[2] Albert, Rubbo, Goldacre and Balfour, *Brit. J. Exp. Path.*, **28**, 69 (1947).
[3] Albert and Goldacre, *J. Chem. Soc.*, 706 (1946).

Arsenolysis and Phosphorolysis of the Amylose and Amylopectin Fractions of Starch

Doudoroff, Barker and Hassid[1] showed that the addition of arsenate to sucrose phosphorylase from *Pseudomonas saccharophila* catalyses the decomposition of sucrose to glucose and fructose, the reaction being:

$$\text{sucrose} + H_2O \xrightarrow[\text{arsenate}]{\text{sucrose phosphorylase}} \text{glucose} + \text{fructose}.$$

We have found that the addition of inorganic arsenate to potato phosphorylase will also cause the liberation of glucose from starch according to the reaction:

$$\text{starch} + H_2O \xrightarrow[\text{arsenate}]{\text{potato phosphorylase}} \text{glucose}.$$

Apparently an intermediate glucose-1-arsenate is formed which does not accumulate but is decomposed rapidly to glucose and arsenate.

However, there is a distinct difference in the limit to which arsenolysis of amylose and of amylopectin proceeds when potato phosphorylase is used. Whereas amylose is practically completely decomposed to glucose by this enzyme in the presence of arsenate, amylopectin is degraded in this process only to approximately 54 per cent (see table).

Likewise, it has been observed that potato phosphorylase acts towards amylose and amylopectin in a similar manner in the process of phosphorolysis. Under conditions in which the amount of amylose is insufficient to allow equilibrium to be reached between glucose-1-phosphate and inorganic phosphate, the amylose is almost completely phosphorolysed to glucose-1-phosphate, but only about 57 per cent of the amylopectin is converted to this ester.

It is interesting to note that such behaviour is characteristic also of β-amylase[2]. In the well-known hydrolytic reaction, amylose is broken down by β-amylase almost completely to maltose, while amylopectin is degraded by this enzyme only to the extent of about 55 per cent. It can therefore be postulated that, like β-amylase, potato phosphorylase acts upon the branched amylopectin through the process of arsenolysis or phosphorolysis, attacking the non-reducing ends, splitting off successive terminal glucose fragments (β-amylase splits off maltose), until it encounters an obstruction. The obstruction is considered to be a modified structure, which is a 1,6-glucosidic linkage at or near the point of branching. With amylose, which has an unbranched structure and therefore no such linkages, arsenolysis or phosphorolysis continues until the whole molecule is degraded. This difference in behaviour of potato phosphorylase towards the amylose and amylopectin components of starch constitutes further evidence that the former component is linear while the latter is branched.

PHOSPHOROLYSIS AND ARSENOLYSIS OF AMYLOSE AND AMYLOPECTIN

Enzyme digest for phosphorolysis consists of 0·05 *M* sodium phosphate and 0·05 *M* sodium maleate buffers at pH 6·65, 2 ml. potato phosphorylase preparation. Total volume of digest, 8 ml. Incubation at 30°.

Enzyme digest for arsenolysis consists of 0·05 *M* sodium arsenate and 0·05 maleate buffers at pH 6·65, 6 ml. of potato phosphorylase (different preparation than used above). Total volume of digest 36 ml. Incubation at 30°.

Substrate	Starch added (mgm./ml.)	Starch phosphorolysed (as percentage of total glucose esterified, ± 3) after		Starch arsenolysed (as percentage of total glucose esterified, ± 3) after	
		4½ hr.	7 hr.	12 hr.	24 hr.
Potato amylose	1·0	102	100	88	89†
"	2·0	66	65*	85	88†
"	4·0	35	35*	—	—
Potato amylopectin	0·5	56	60		
"	1·0	57	58	51	54
"	2·0			48	53
Tapioca amylopectin	0·5	56	58		
"	1·0	55	56		

* Starch incompletely phosphorolysed because equilibrium between glucose-1-phosphate and inorganic phosphate had been reached. Excess of starch does not affect the equilibrium.

† The fact that the reaction does not go to completion is probably due to the small amount of retrogradation of amylose that occurs during the experiment.

JOSEPH KATZ
W. Z. HASSID

Division of Plant Nutrition,
College of Agriculture.

MICHAEL DOUDOROFF

Department of Bacteriology,
University of California,
Berkeley, California.

[1] Doudoroff, M., Barker, H. A., and Hassid, W. Z., *J. Biol. Chem.*, **170**, 147 (1947).

[2] Samec, M., and Waldschmidt-Leitz, Z., *Physiol. Chem.*, **203**, 16 (1931). Hanes, C. S., *New Phyt.*, **36**, 189 (1937). Meyer, K. H., and Bernfeld, P., and Press, J., *Helv. Chim. Acta*, **23**, 1465 (1940). Hassid, W. Z., and McCready, R. M., *J. Amer. Chem. Soc.*, **65**, 1154 (1943).

Reaction of Boric Acid with Polysaccharides

MANY polyhydroxy compounds of low molecular weight are known to form complexes with boric acid in aqueous solutions, as numerous investigations (Böeseken *et al.*) have shown. These complexes are much more easily obtained from cyclic glycols possessing the *cis* configuration than from the *trans* isomers. One boric acid molecule may react with either one or two 1,2-glycol molecules; in the latter case a 'boron spirane' is formed.

No systematic and theoretical investigations concerning boric acid – polysaccharide compounds have been published. Irany[1] studied the effect of boric acid on various substances of high molecular weight in the absence of water. Cross-linking was observed especially in substances in which the macromolecules carried non-adjacent hydroxyl groups. The Pharmacopœia Helvetica V mentions the incompatibility of borax with gum arabic (gel formation). The gelification of aqueous solutions of *Ceratonia siliqua* mucilage by borax has been observed repeatedly[2].

It is to be expected that polysaccharides characterized by adjacent hydroxyl groups in the *cis* configuration will form boron spiranes in the presence of water. If chain molecules are employed, this reaction should lead to the formation of three-dimensional networks (gelification). Experiments with numerous polysaccharides of known composition[3] have shown that only those substances possessing the postulated configuration tend to form chelate esters: mannan from tubers of *Orchis morio*, mono-glycol ester of alginic acid (polymannuronic acid) and galacto-mannans from the endosperm of *Ceratonia siliqua* and *Trigonella fœnum græcum*. Aqueous solutions containing even less than 0·3 per cent polysaccharide are transformed into jellies by the addition of borax, provided that the degree of polymerization of the chain molecules is sufficiently high. Because of its more spherical macromolecules and its low content of rhamnose[4], gum arabic, even

at extremely high concentrations, possesses only a small tendency to jellify. Aqueous solutions of the methyl and mono-glycol ester of pectic acid (polygalacturonic acid) do not jellify when borax is added. However, cross-linking takes place, if the mono-glycerol ester which carries the required diol group is used.

All the above-mentioned jellies are not formed under acidic conditions. The gels are liquefied by treatment with compounds of low molecular weight which are known to form complexes with boric acid (for example, mannitol, fructose, glycerol, but not sucrose). Their mechanical properties (ropiness, plasticity) can be explained on the assumption that the cross-linkages are not fixed but perpetually destroyed and rebuilt.

It is of interest to note Lopatkin's observation[5] on the agglutination of *B. Shiga-Kruse* by boric acid. This micro-organism produces a polysaccharide which contains rhamnose[6]. Certainly many other mucilages found in animals, plants and micro-organisms will react with borax in a similar manner to the above-mentioned substances. The reaction described might prove to be valuable to macromolecular chemistry and bacteriology. Adjacent hydroxyl groups in the *cis* configuration can thus be identified.

These investigations will be published in full elsewhere.

H. Deuel
H. Neukom
F. Weber

Agrikulturchem. Institut,
Eidg. Tech. Hochschule,
Zurich.
Dec. 15.

[1] Irany, E. P., *Ind. Eng. Chem.*, **35**, 1290 (1943); *Colloid Chem.*, **6**, 1089 (1946).
[2] Williams, A. L., *Analyst*, **53**, 414 (1928). Hart, R., *Ind. Eng. Chem. Anal. Ed.*, **2**, 329 (1930). Jacobs, M. B., and Jaffe, L., *Ind. Eng. Chem. Anal. Ed.*, **3**, 212 (1931).
[3] Hirst, E. L., and Jones, J. K. N., *J. Soc. Dyers and Col.*, **63**, 249 (1947).
[4] Smith, F., *J. Chem. Soc.*, 1035 (1940).
[5] Lopatkin, A. P., cited in *Chem. Abst.*, **36**, 2885 (1942).
[6] v. Stacey, M., "Advances in Carbohydrate Chemistry", **2**, 161 (1942).

Constitution of Monazite

X-RAY examination of monazite has been carried out by Hadding[1], Gliszczynski[2] and Parrish[3], and the space group and crystal class uniquely determined. According to Goldschmidt[4], the thorium which is usually present is 'captured' during crystallization of the phosphate from its parent magma because of its favourable ionic size. To compensate for the increased cationic charge of the thorium ion, the resulting lattice must possess a defect structure in which some of the sets of equivalent cationic positions are only partially occupied. The quantity of thorium which can be tolerated in such a structure is not known, but monazites the thoria content of which varies from nil to at least 18 per cent (approximately 0·2 atoms per atom of rare earth element) have been reported[3,5].

While there is agreement about the gross structure of the mineral, the role of certain minor constituents, particularly silica, has not been satisfactorily explained[5]. Many components reported in monazite analyses are undoubtedly due to the presence of a considerable proportion of extraneous heavy minerals which, because of high specific gravity or other factors, have not been removed from the sample. This is the case with much of the iron, tin, chromium, titanium, and probably zirconium in samples of alluvial or littoral origin. Petrographic examination reveals that even single crystals of monazite are seldom free from inclusions of foreign substances. Microscopical observations reveal a much greater degree of homogeneity, however, in some fine-grained monazites obtained from beach sands, natural processes having effectively separated the grains from associated minerals.

The proportion of inclusions in such material is scarcely sufficient to account for the percentage of impurities given by chemical analysis of the sand, even after allowance has been made for the small quantity of extraneous material (insoluble in sulphuric acid) which remains in the sand after repeated magnetic and other separations. It is not unreasonable, therefore, to suppose that some at least of the 'impurities' occupy positions in the lattice of the mineral, for example, silica (usually present to the extent of about 0·5–1 per cent), lime (about 0·2 per cent), urania (about 0·2 per cent UO_2), and other oxides in smaller amounts. Thus calcium and tetravalent uranium, like thorium, could be easily accommodated because of favourable ionic size[4,6].

Marshall[7] has commented on the replacement of silicon by phosphorus in certain silicate structures. A similar replacement appears to occur in certain varieties of zircon rich in phosphorus[8]. The reverse phenomenon is observed in the apatite minerals wilkeite[9] and ellestadite[10], and in the mineral abukumalite, for which Shin Hata[11] has found the ratio Si/P to be 4. The replacement of silicon by phosphorus arises from the comparable size and regular tetrahedral structure of the groups SiO_4 and PO_4[6,12,13]. The possibility arises, therefore, that silica in monazite is present in the phosphate lattice to the extent of about 1 silicon atom for 23 phosphorus atoms. A defect structure with some unoccupied anionic positions would compensate for the increased charge of the phosphorus ion. Conceptions such as these would account both for the variable quantities of thorium and silicon in the lattice and for the variable thorium to silicon ratio observed, thus overcoming the difficulties of the earlier theory of solid solution of thorium silicate in rare earth phosphate, a theory which was shown to be untenable because it demanded constancy of the thorium to silicon ratio.

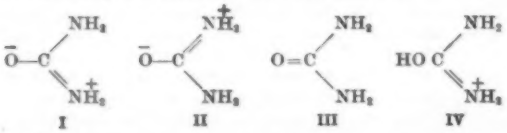
A. W. Wylie

Division of Industrial Chemistry,
Council for Scientific and Industrial
Research, Melbourne.
Sept. 26.

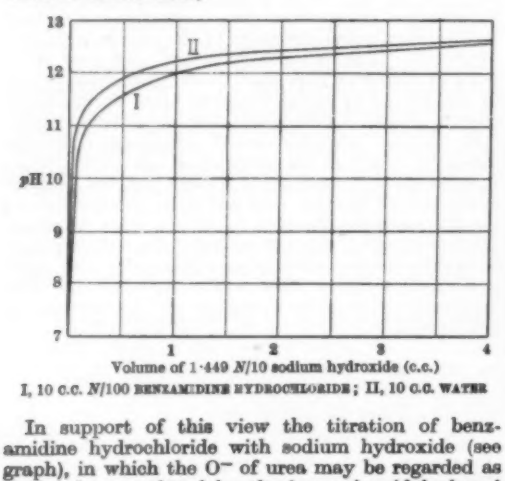
[1] Hadding, A., *Z. anorg. Chemie*, **122**, 195 (1921).
[2] Gliszczynski, S., *Z. Krist.*, (A), **101**, 1 (1939).
[3] Parrish, W., *Amer. Min.*, **24**, 651 (1939).
[4] Goldschmidt, V. M., *Chem. Prod.*, **7** (5–6), 29 (1944).
[5] Mellor, J. W., "A Comprehensive Treatise on Inorganic and Physical Chemistry", **5**, 526 (Longmans, London).
[6] Hassell, O., "Crystal Chemistry", trans. Evans, R. C., 11, 24, 28 (Heinemann, London, 1935).
[7] Marshall, C. E., *Z. Krist.*, (A), **91**, 433 (1935); *J. Soc. Chem. Ind.*, **54**, 393 (1935).
[8] Shin Hata, *Sci. Papers Inst. Phys. Chem. Res.* (Tokyo), **34**, 619 (1938).
[9] Eakle, A. S., and Rogers, A. F., *Amer. J. Sci.*, **37**, 262 (1914).
[10] McConnell, D., *Amer. Min.*, **22**, 977 (1937).
[11] Shin Hata, *Sci. Papers Inst. Phys. Chem. Res.* (Tokyo), **34**, 1018 (1938).
[12] Wells, A. F., "Structural Inorganic Chemistry", 418 (Oxford Univ. Press, London, 1935).
[13] Pauling, L., "The Nature of the Chemical Bond", 240 (Cornell Univ. Press, New York, 1940).

Structure of Urea

CONSIDERABLE evidence[1] has been presented for the polar structures I and II as important contributory forms of urea in aqueous solution and in the solid state. This view has been criticized by Bell, Gillespie and Taylor[2] on the grounds of electrometric titration data. The observation that buffering of urea solutions can only be detected at low *p*H values has been interpreted by these authors to mean that urea is a weak monacid base having the uncharged structure III. This result, however, would appear to be compatible with the polar structure of the molecule.



Either resonance structure I or II may be regarded as a substituted amidine in which the normal basic strength of this group has been considerably increased by the strong anionoidal characteristic of the attached O^- ($+I$; $+T$). This amidine ion would impart strong acid properties to the hydroxyl group of structure IV, of which urea may be regarded as the acid ion. The acid titration of urea may then be regarded as the back titration of a strong acid ($K > 10^{-1}$), and the alkaline titration as the back titration of a strongly basic substituted amidine, of such strength that buffering is absent in aqueous sodium hydroxide (cf. Bjerrum[3] on the titration data of amino-acids).



I, 10 c.c. *N*/100 BENZAMIDINE HYDROCHLORIDE; II, 10 c.c. WATER

In support of this view the titration of benzamidine hydrochloride with sodium hydroxide (see graph), in which the O^- of urea may be regarded as having been replaced by the less anionoidal phenyl radical, shows slight buffering. The dissociation constant as computed from these data is of the order of $K_{20} = 10^{-2 \cdot 3}$.

J. O. HARRIS
A. H. ROBSON

Chemistry Department,
University of Durham,
King's College,
Newcastle-upon-Tyne.
Sept. 26.

[1] For refs. see Taylor and Baker, "Organic Chemistry of Nitrogen", 280 *et seq.* (Oxford, 1937).
[2] Bell, Gillespie and Taylor, *Trans. Farad. Soc.*, **39** 137 (1943).
[3] Bjerrum, *Z. phys. Chem.*, **104**, 147 (1923).

Spread of Detonation in High Explosives

IN a recent communication[1], W. C. F. Shepherd makes the interesting observation that in the initial stages of detonation in a cylindrical cartridge of high explosive initiated with a detonator, a phase, referred to as the pre-detonation phase, is often noticeable during which the rate of propagation of the reaction is much lower than the stable value finally established. Moreover, "with progressively stronger initiators, the extent of the pre-detonation phase was correspondingly reduced and the rate of propagation during this phase was increased until, finally, there was no perceptible delay in the inception of detonation".

Having had occasion to study this phenomenon, we can confirm that, in certain high explosives, the detonation set up by a detonator may be of a lower order than that which eventually develops. In such cases, there is an initial unstable phase during which the reaction accelerates more or less rapidly until a point is reached at which the rate of detonation changes abruptly to a much higher value. This phenomenon is fairly common among liquid and gelatinous explosives and is illustrated in photographs Nos. 2, 7 and 10 of a previous paper by one of the present writers[2]. It is not generally known, however, that this effect can be produced in granular solid explosives like crystalline or granulated T.N.T. or tetryl, and that, under suitable conditions, such explosives exhibit the property, usually attributed only to liquid and gelatinous explosives, of being able to propagate detonation at two distinct velocities.

Fig. 1

Fig. 3 Fig. 2

The photograph reproduced in Fig. 1 illustrates the case where the initial regime is unstable and, after travelling a certain distance, changes abruptly to the higher detonation level. This record, which is almost identical with that of Shepherd, was obtained with a 1-in. diameter cartridge of granulated tetryl, size 20–30 B.S.S., cartridged at a density of 0·94 gm./c.c. and initiated with a No. 6 A.S.A. detonator. As Shepherd points out, the length of the

initial phase varies with the strength of the initiator and can be eliminated altogether by using a sufficiently powerful initiator. Another interesting feature is that it also depends on the grist of the explosive, the density of packing, and the diameter of the cartridge. With high-density compressed cartridges, as used by W. Weibull[3], the high-velocity regime is usually set up immediately, even with detonator initiation. On the other hand, with low-density packing, as used by Shepherd, the low-velocity regime may be initiated first. In the latter case, by using a sufficiently narrow cartridge, or, alternatively, a sufficiently coarse grist of explosive, the low-order detonation can be made to travel throughout the full length of the cartridge (at least a metre) at a rate which is both uniform and repeatable. It appears, therefore, that the explosive has a specific and stable 'low' velocity of detonation under these conditions. On the other hand, if a sufficiently powerful initiator is used, the same cartridge propagates detonation at a greatly enhanced speed, the rate of detonation being again uniform and repeatable.

Figs. 2 and 3 illustrate this point and show the 'low' and 'high' velocities of detonation in identical cartridges of granular solid explosive. The explosive in this case was flake T.N.T., size 20–30 B.S.S., cartridged at a density of 1·0 gm./c.c., the diameter of the cartridge being 1 3/16 in. The cartridge in Fig. 2 was initiated with a No. 6 A.S.A. detonator and gave a velocity of detonation of 1,120 m./sec.; that in Fig. 3 was initiated with a 12·5 gm. tetryl pellet and gave a velocity of detonation of 3,660 m./sec. The length of the cartridge in each case was 10 in., but tests with cartridges up to 1 metre in length showed no indication of any significant change in velocity of detonation with distance along the cartridge.

It is interesting to note that the low-velocity detonation appears to be characterized by incomplete decomposition of the explosive in the sense that some of the original explosive remains chemically unchanged. Visual evidence of this is to be found in the fact that the cloud formed on detonating T.N.T. or tetryl in the open appears white when detonation occurs at the low velocity and black when the high velocity is operative. It will also be seen from the photographs, especially Fig. 1 where the transition point is represented, that the luminosity is much more intense in the high-velocity region than in the low. The presence of undecomposed explosive in the residue remaining after a shot has also been confirmed by chemical tests; and it is remarkable that, even with a sensitive explosive like nitroglycerine, a considerable proportion of the explosive may be scattered without decomposing if the cartridge is below a certain diameter and is initiated with a detonator below a certain strength.

ELWYN JONES
DUGALD MITCHELL

Research Department,
Imperial Chemical Industries, Ltd.,
Explosives Division,
Stevenston,
Ayrshire.
Sept. 23.

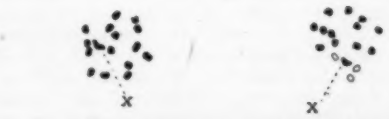
[1] Shepherd, W. C. F., *Nature*, **160**, 92 (1947).
[2] Jones, E., *Proc. Roy. Soc.*, A, **120**, 603 (1928).
[3] Weibull, W., *Nature*, **159**, 402 (1947). Mitchell, D., and Paterson, S., *Nature*, **160**, 433 (1947).

Chromosome Number of *Sesamum laciniatum* Klein

Sesamum laciniatum is a wild species which is reported to occur with another wild species, *S. prostratum* Retz., in south India[1]. The two species resemble each other closely in their morphological characters except for the fact that the leaves of *S. laciniatum* are more deeply pinnatifid than those of *S. prostratum*. Besides these two wild species, the only other representative of this genus in India is *S. orientale* L. (= *S. indicum* D.C.), which is the common cultivated *til*.

Cytogenetical studies on *S. orientale* and *S. prostratum* have been in progress in this laboratory for some years past[2,3,4]. Attempts were made to collect seeds of *S. laciniatum* for the inclusion of this species in the studies in progress, and some were obtained in November 1945 through the courtesy of one of the postgraduate students of this Division, Mr. Syed Murtaza Hasan, who collected them from plants growing in the vicinity of Hyderabad (Deccan). More seed of this species was also obtained later from plants growing in the Coimbatore district in South India.

Fig. 1



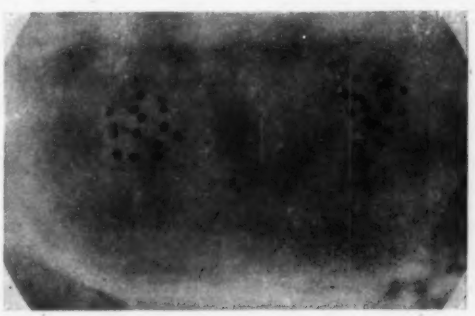


Fig. 2

The seeds were germinated after removing their tough seed coats, and a few plants were raised to maturity and identified as belonging to the species *S. laciniatum*. Aceto-orcein preparations of pollen mother cells were examined for chromosome number. It was noticed in a large number of cells, at metaphase II, that the chromosomes were distributed as 16 + 16 at the two poles (Figs. 1 and 2). The somatic chromosome number of this species was also determined in the root-tip cells as 32 (Fig. 3). It is not surprising that the chromosome number of this species is the same as that of *S. prostratum*, namely, $2n = 32$, considering its close similarity to the latter in morphological characters and distribution in Nature. One peculiarity was, however, noticed in that almost invariably, at second meiotic metaphase, one chromosome in each group of daughter chromosomes was very much less stained than the others and also showed very much less condensation (Fig.

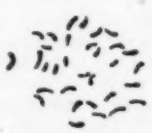


Fig. 3

1, *x*). Further studies on this species are in progress.

It may be mentioned in this connexion that recently Raghavan and Krishnamurthy[5] have reported the chromosome number of this species as $2n = 28$.

S. Ramanujam
A. B. Joshi

Division of Botany,
Indian Agricultural Research Institute,
New Delhi. Sept. 6.

[1] Hooker, J. D., "Flora of British India", **4**, 387 (1885).
[2] Ramanujam, S., *Curr. Sci.*, **10**, 439 (1941).
[3] Ramanujam, S., *Curr. Sci.*, **11**, 426 (1942).
[4] Ramanujam, S., *Curr. Sci.*, **13**, 40 (1944).
[5] Raghavan, T. S., and Krishnamurthy, K. V., *Curr. Sci.*, **14**, 152 (1945).

Mustard-gas Mutation in *Aspergillus nidulans*

The production of 'biochemical mutants' of fungi by means of ultra-violet or X-radiation has been reported by Beadle and Tatum[1,2] (*Neurospora* spp.), Fries[3,4,5,6] (*Ophiostoma* spp.) and Pontecorvo[7] (*Aspergillus* and *Penicillium* spp.). Following the use of mustard-gas (β,β′-dichlorodiethyl sulphide) in producing mutations in the vinegar fly (*Drosophila melanogaster*) by Auerbach and Robson[8], this reagent has been used by Horowitz *et al.*[9] to produce mutations in *Neurospora* spp. A method for isolating strains of *Aspergillus nidulans* deficient for a specific amino-acid, cystine, from a mixture of mutants produced by mustard-gas, is now described. These special mutants grow normally in presence of cystine but are unable to grow with sulphate as sole sulphur source.

A dark green 'conidial' strain of the mould, called *A*69 by Dr. Yuill who kindly supplied it, was found by Dr. Pontecorvo to be particularly suitable for the production of X-ray mutants. Seven-day cultures on 10 cm. Petri dishes of maltwort-agar were each exposed to the vapour from three drops of mustard-gas on a 3·5 cm. Whatman No. 1 paper; ¾-in. disks of mycelium were removed. Those in which the viable count had dropped to about 3,000 (on cystine-containing medium) were used for isolation of mutants. Spore-suspension from a disk was incubated for 16 hr. in a thin layer of liquid cystineless medium (sulphate as source of sulphur). The suspension was then filtered through glass wool to remove a greater part of the already germinated spores, that is, those capable of using sulphate. By this means the number of viable spores were reduced 10–15 times. The technique is an adaptation of one used by Fries[10]. The resultant suspension was plated on cystine-containing medium.

At this stage in various experiments there have been noted morphological mutants of many types; for example, white, yellow, yellow-green and cinnamon 'conidial' types, many white and one purple 'mycelial' types, 'perithecial' types and pigment producers. In the experiment quoted, 68 different morphologues (mostly white types) appeared from 640 viable spores. A control test on non-exposed material gave two morphologues out of 1,480. Dr. Pontecorvo has made similar observations on X-ray mutations.

Material from each colony was inoculated on to solid cystineless medium. Those inoculations which only grew a few spidery threads were tested on cystineless and cystine-containing media. Those giving no growth or only a few spidery threads on the former were checked against both media again. Four such isolates were obtained.

To date, thirteen such mutants have been obtained. Some of these tested by Dr. Pontecorvo form 'balanced' heterokaryons with some of his mutants deficient for certain amino-acids.

Full details of media, methods and observations on the exact nature of the biochemical deficiencies will be published elsewhere.

Donald Hockenhull

College of Technology,
Manchester.
Sept. 23.

[1] Beadle, G. W., and Tatum, E. L., *Proc. U.S. Nat. Acad. Sci.*, **27**, 499 (1941).
[2] Tatum, E. L., and Beadle, G. W., *Proc. U.S. Nat. Acad. Sci.*, **28**, 234 (1942).
[3] Fries, N., *Svensk. Bot. Tidskr.*, **39**, 270 (1945).
[4] Fries, N., *Svensk. Bot. Tidskr.*, **40**, 127 (1946).
[5] Fries, N., *Nature*, **158**, 757 (1946).
[6] Fries, N., *Arkiv för Botanik* (Uppsala), **33**, 1 (1946).
[7] Pontecorvo, G., Cold Spring Harbor Symposia on Quantitative Biology, **11**, 193 (1946) and personal communication.
[8] Auerbach, C., and Robson, J. M., *Nature*, **157**, 302 (1946).
[9] Horowitz, N. H., Houlahan, M. B., Hungate, M. G., and Wright, B., *Science*, **104**, 233 (1946).
[10] Fries, N., *Nature*, **159**, 199 (1947).

A Vasodilator, Adrenolytic Substance in Aglomerular Fish Kidney

Experiments were performed on aglomerular fish kidneys to establish the presence or absence of vaso-active substances. This communication deals with the presence of an adrenolytic, vasodilator substance in extracts of the aglomerular kidneys of the toadfish (*Opsanus tau*). The material extracted was tested for its vasodilator properties on the peripheral blood vessels and capillaries of the frog (*Rana pipiens*), and also for its adrenolytic ability, that is, ability to neutralize and protect against the vasoconstrictor effect of epimephrine.

Material and Methods. Toadfish (*Opsanus tau*), a marine fish which is a normal inhabitant of the deep waters of the Atlantic coast, were obtained by seining in Buzzards Bay off Woods Hole, Mass., and brought to the Marine Biological Laboratory. The fish were kept in aquaria supplied with a continuous stream of sea water and treated as indicated below. The fish were removed from the aquarium and placed in a solution of sea water containing 5–7·5 per cent of ether, C.P. Some fish were anæsthetized by being placed in a bucket containing cracked ice. The fish used varied in size from 8 to 10 in. in length. When anæsthetized, they were placed in a holder ventral side uppermost, and the abdomen opened by a V-shaped incision, commencing above the anal aperture, and extending anteriorly along both sides up to the pectoral fins. The kidneys were dissected free and weighed. Immediately after weighing, they were ground with sand and acid alcohol (95 per cent ethyl alcohol to which 0·1 per cent concentrated sulphuric acid had been added; *p*H approximately 3·5). After being thoroughly homogenized, enough acid alcohol was added to make the final volume approximately 4 ml. for each gram of kidney. Material and solvent were then placed in a shaker, shaken for twelve hours and treated further according to the method previously published[1,2].

The final product was dissolved in distilled water in an amount in which 1·0 ml. represented the equivalent of material obtained from 1·0 gm. of toadfish kidney. In preliminary chemical tests, it was found to be protein-free (sulphosalicylic acid test), negative with the biuret test, *p*H 4·5–5·0.

The vasodilator effect was studied in the web of medium-sized frogs (*Rana pipiens*). Frogs were pithed and the circulation in the web was observed with a low-power microscope. In the control studies of ten frogs, the diameter of the capillaries was 12–15 microns. The amount of epinephrine injected sufficient to bring the circulation in the web to a standstill was determined by injecting increasing doses beginning with 10 gamma of stock solution (1 : 100,000). 1 ml. of toadfish kidney extract prepared as indicated above was then injected into the lateral lymph sac, and the effect on the capillary vessels, a-v anastomoses, arterioles and venules observed. After the effect was fully established, amounts of epinephrine equal to that required to arrest the circulation were then injected, as well as multiple dosages (2–10 times the amount). In the ten frogs thus studied, all showed a definite increase in the diameter of the capillaries to 20–30 microns following the injection of toadfish kidney extract. In nine out of ten frogs there was complete protection against subsequent administration of epinephrine in doses varying from 100 to 500 gamma (1 : 10,000–1 : 2,000).

Similar results have been reported with an extract obtained from mammalian kidneys, named 'tubulin'[2].

Extracts of toadfish liver similarly prepared failed to produce vasodilation or neutralize or protect against epinephrine in similar dilutions.

A more extensive report of these studies will be published in the near future.

I wish to express my thanks to Dr. Charles Packard, director of the Marine Biological Laboratory, Woods Hole, Mass., for the material and laboratory facilities made available for these studies.

BENJAMIN JABLONS

New York Polyclinic Hospital
and Medical School,
New York.
Sept. 22.

[1] Jablons, B., *Trans. Amer. Physiol. Soc.* (1935).
[2] Jablons, B., *N.Y. State J. Med.*, **38**, No. 1 (1938).
[3] Cope, Otis M., and Jablons, B., *Fed. Proc.*, **2**, 90 (1947).

Quantitative Relation Between Salt Accumulation and Salt Respiration in Plant Cells

LUNDEGÅRDH[1,2] has shown how the salt or anion respiration could provide a mechanism of accumulation by transporting anions into the cell. This hypothesis postulates a mechanism whereby anions are transported by an electron carrier (probably cytochrome) in the direction opposite to electrons, and whereby cations exchange for hydrogen ions; both electrons and hydrogen ions enter into the formation of water in the respiratory process. Both ions of a salt are accumulated.

If the Lundegårdh hypothesis is valid, the maximum rate of accumulation should occur when each electron leaving via the oxidase system is exchanged with an anion from the external solution. In this respiration all the molecular oxygen concerned in the process is combined to form water, and each molecule of oxygen therefore requires four electrons and four hydrogen ions. The maximum rate of salt accumulation should therefore be 4 gm. mol. monovalent salt accumulated per gm. mol. oxygen utilized, or,

$$\frac{\text{salt accumulation}}{\text{salt respiration}} = 4.$$

This quantitative relationship is not shown in Lundegårdh's results[2]; but experiments with carrot tissue indicate that, under appropriate conditions, the ratio approaches the theoretical value.

In all experiments, the salt respiration-rate has been taken as the difference between the rate in water and rate in salt solution, which, in well-washed carrot tissue, is equivalent to the cyanide-sensitive respiration[4]. The rate of accumulation, taken over the few hours immediately after the initial equilibration[5], is at its maximum. The results of experiments with various batches of carrots are given in the accompanying table.

Concentration of potassium chloride	No. of observations	Mean of ratio Accumulation-rate / Respiration-rate
0·00063 *M.*	2	0·44 ± 0·16
0·00125	2	1·60 ± 0·73
0·0025	1	2·09
0·005	6	2·26 ± 0·41
0·01	19	2·88 ± 0·84
0·02	16	2·78 ± 0·62
0·03	4	3·00 ± 0·23
0·04	6	3·17 ± 0·79
0·05	8	3·39 ± 0·70
0·06	4	3·38 ± 0·37

At the higher concentrations the ratios approach the hypothetical value. Both salt accumulation and salt respiration-rates increase asymptotically with increasing concentration, but the salt respiration-rate approximates to the asymptote at lower concentrations than does the salt accumulation-rate. This accounts for the significantly lower ratios observed at low concentrations. Results of the same order of magnitude have been obtained with other halides on carrot tissue, and with beet tissue[6] and barley roots[7].

Comparison of these with other relevant data in the literature indicates that: (1) low concentrations give low ratios; this probably accounts for the low ratios calculated from Lundegårdh's results with low concentrations of salt on wheat roots; (2) at higher concentrations when neither accumulation nor salt respiration is limited, the ratio approaches that required by the theory of ion transport by an electron carrier.

This work will be published in full elsewhere. We wish to express our thanks to Prof. J. S. Turner and Dr. J. R. Vickery.

R. N. ROBERTSON
MARJORIE WILKINS

Division of Food Preservation and Transport,
Council for Scientific and Industrial Research,
Homebush, New South Wales.
Sept. 23.

[1] Lundegårdh, H., *Ark. Bot.*, **32A**, 1 (1945).
[2] Lundegårdh, H., *Nature*, **157**, 575 (1946).
[3] Lundegårdh, H., *Ann. Agric. Coll. Sweden*, **8**, 234 (1940).
[4] Robertson, R. N., and Turner, J. S., *Aust. J. Exp. Biol. and Med. Sci.*, **23**, 63 (1945).
[5] Robertson, R. N., *Aust. J. Exp. Biol. and Med. Sci.*, **22**, 237 (1944).
[6] Robertson, R. N., Turner, J. S., and Wilkins, Marjorie J., unpublished data.
[7] Milthorpe, Joan, and Robertson, R. N., unpublished data.

Aggression, a Component of Post-Epileptic Automatism in *Peromyscus*

CONVULSIVE seizures of rodents have been described in rats[1–4] and in *Peromyscus*[5]. Although various types of convulsive seizures exist, the epileptic form is common to all the strains of animals in which a seizure can be precipitated by specific sounds (audiogenic), and is also induced by other methods. This type has the following general form: a period of

disorientated running is succeeded by a clonic phase or by clonic-tonic convulsions, terminating either in a spastic state, catalepsy or exhaustion.

Our studies on a strain of epileptic *Peromyscus* (*maniculatus-artemesisiæ*, received from Dr. L. R. Dice, Ann Arbor, Michigan) have revealed a new component of the behaviour in the post-convulsive phase. While convulsing two litter-mate animals together in the same enclosure, the animal which recovered first from the fit made a savage attack on the other, biting and holding it with the fore-paws.

Typically we have observed 'bouncing' convulsions lead to a prostrate clonic phase during and after which the jaws of the mouse are constantly in motion, and it may sometimes bite its own feet. The animal recovers while still undergoing clonic movements, and then runs and hops round the cage with retroverted head. In this phase it will follow and attack other mice or attack models and occasionally attempts to bite the floor. Sometimes the attacks are interrupted by clonic movements which loosen its hold on the attacked object. Otherwise it may crawl over the model, attacking it in many places, or make repeated sallies at the same model. Finally, it halts, shaking with ears extended, hairs on the back erect and with its head and tail raised.

Referring to the latter part of the 'bouncing' fits, Watson[5] says, "After 5 to 20 seconds of clonic convulsions most of the mice in this condition will take hold of the cotton which surrounds the tin enclosure in which they are tested; they hang along the cotton with their feet or teeth for several minutes until they are able to walk away". This attitude, we suggest, is really an attack. Hamilton[2], describing the post-convulsive symptoms of his rats, mentions that "After the convulsive attack the animal relapses into a 'coma' which may last from a few seconds to as long as thirty minutes. If it is of short duration the animal usually is subsequently hypersensitive, squealing, jumping and biting violently when touched," and "During the later stages of the coma the animal may make aimless head movements from side to side or chew on objects that reach his mouth, such as sawdust, other rats, his own paws and frequently his tail, which because of a characteristic sitting position is readily accessible".

This behaviour is in many respects the same as that discovered by us, except that the 'coma' prevents the animal from making an assault. Apparently, observers working with *Peromyscus* have missed this component of the fits because they have only reported observations on solitary animals. Later work on a number of animals of both sexes has confirmed our original observation, the aggression occurring towards the end of a 'bouncing' clonic convulsion with marked regularity in young animals. Not only do they make attacks on cage mates which are not attacked between fits, but they chase and attack other mice. The attacks are also made on models and in the presence of a number of different models, such as a stuffed *Peromyscus* pelt, a cotton-wool roll and a 'Plasticine' model; the wool- and fur-covered models are attacked preferentially. The aggression is, therefore, part of a co-ordinated phase of behaviour and is thus an automatism. This suggests that the hopping and running of the mice in this phase are also automatic phenomena, due to a "return of activity to the lower centres" before the derangement of the neural mechanism has been restored to normal[6].

In view of the close similarity of audiogenic convulsions in *Peromyscus* and rats, it would be interesting to know if post-convulsive aggression occurs in any of the different strains of rats subject to this type of abnormal behaviour.

As aggression is a component of post-ictal automatisms in man[6], the discovery of an aggression in the behaviour of *Peromyscus* following audiogenic seizures adds a further point to the evidence suggesting a close similarity between this type of abnormal behaviour in rodents and epilepsy in man.

M. R. A. Chance

Pharmacology Department,
Medical School,
University of Birmingham.
Sept. 26.

[1] Maier, N. R. F., "Studies of Abnormal Behaviour in the Rat" (Harper Bros., 1939).
[2] Hamilton, J. R., *J. Comp. Psychol.*, **33** 297 (1942).
[3] Hall, C. S., and Martin, R. F., *J. Psychol.*, **10**, 207 (1940).
[4] Griffiths, W. J., jun., *J. Comp. Psychol. Monographs*, **17**, No. 8, SN92 (1942).
[5] Watson, M. L., Contributions from the Laboratory of Vertebrate Genetics, No. 11 (July 1939).
[6] Penfield, W., and Erickson, T. C., "Epilepsy and Cerebral Localisation" (1941).

Absorption of Protein and Bacteria from Normal and Infected Joints

Knee joints of rabbits were infected by intra-articular injection of staphylococci. In some cases a diluted solution of a standardized staphylococcus filtrate was used instead. The absorption of protein from the joint cavity was tested by means of 5·5 gm. per cent solution of human hæmoglobin in isotonic saline containing 10 mgm. per cent of calcium. Living radioactive bacteria used in absorption tests were prepared by growing *Mycobacterium phlei* on a Sauton substrate containing radiophosphorus.

The following observations were made. During the first hour of infection, the absorption of hæmoglobin is increased above normal. Two to three hours after infection, the rate of absorption of hæmoglobin is temporarily decreased below normal. The decrease lasts only a few hours. Heparinization of the animals prevents this decrease of absorption; instead, an increased absorption of hæmoglobin, as great as during the first hour after infection, prevails for several hours. The absorption of radioactive bacteria injected one hour after the infection is greatly reduced whether heparin is given or not. In joints inflamed by means of a diluted culture filtrate, the absorption of hæmoglobin is increased far above normal. This increase is partly prevented by large doses of desoxycorticosteroneacetate. Desoxycorticosteroneacetate, however, has no effect on the absorption of hæmoglobin from normal joint cavities.

The results confirm previous statements by Menkin[1] that in staphylococcus inflammation the absorption of colloids is partly blocked by fibrin clots. The formation of these clots is prevented by heparin. The fact that the absorption of radioactive bacteria is blocked in spite of heparin shows that this block has a different origin. Control experiments on benzene-poisoned animals are in progress in order to investigate if the partly blocked absorption of bacteria depends on leucocytic action.

Torbjörn Edlund

Institute of Physiology,
University of Uppsala.
Sept. 27.

[1] Menkin, V., *J. Exp. Med.*, **53**, 171 (1931).

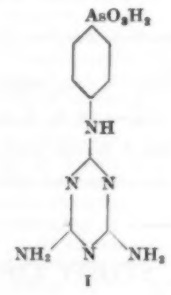
'MELARSEN' AND 'MELARSEN OXIDE'

By J. WILLIAMSON
May and Baker Research Fellow

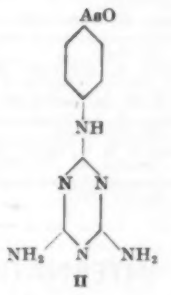
and Dr. E. M. LOURIE
Director, Department of Chemotherapy, Liverpool School of Tropical Medicine

Activity Against Tryparsamide-Resistant Trypanosomes

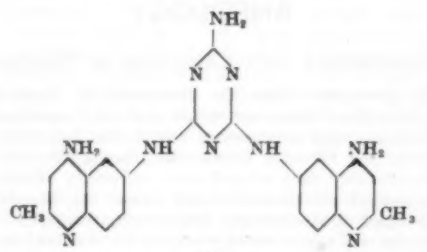
THE melaminyl arsonate, 'Melarsen', that is, the di-sodium salt of 4-melaminylphenylarsonic acid [I], and the corresponding arsenoxide, 'Melarsen oxide' [II], have been suggested for the therapy of *T. gambiense* sleeping sickness[1,2,3]. The most recent published statement on field trials of the latter compound is by Van Hoof[4], who mentions that it is effective against cases of tryparsamide-resistant sleeping sickness. There seems, however, to have been no publication, as yet, of any trials in laboratory infections which might give solid support to the expectation of efficacy in such cases. We have therefore tested the point by comparing the action of 'Melarsen oxide' on our laboratory strain of *T. rhodesiense* and on its tryparsamide-resistant offshoot. (*T. rhodesiense* is not normally sensitive to tryparsamide and other arsenicals, but in the course of many years of mouse-passage our strain has acquired a high degree of sensitivity, and tests against laboratory infections of this strain have proved to be a reliable screening method for the selection of compounds for use against *T. gambiense* infections in man.)



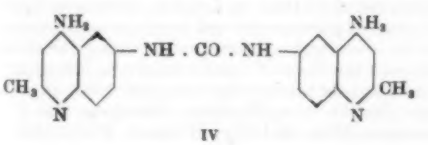
I



II



III



IV

Mice were treated on the second day after intraperitoneal inoculation of 2×10^4 trypanosomes, when the blood contained about 1 to 10 parasites per microscope field (⅛th obj.). 'Mapharside', 3-amino-4-hydroxyphenylarsenoxide, was used instead of tryparsamide to confirm that the tryparsamide-resistant offshoot had retained its resistance unimpaired since this character was acquired eighteen years ago[5].

TABLE 1. EFFECTS OF 'MAPHARSIDE' AND 'MELARSEN OXIDE' ON INFECTIONS OF THE PARENT STRAIN AND TRYPARSAMIDE-RESISTANT OFF-SHOOT OF *T. rhodesiense* IN MICE

Drug	Trypanosome strain	Dose (intraperitoneal), mgm./20 gm.				
		0·2	0·1	0·025	0·015	0·01
'Mapharside'	Parent	4 4C	5 5C	10 1C 9R	33 1C 29R 3N	15 8R 7N
	Resistant	8 8N	5 5N			
		0·05	0·025	0·01	0·005	0·0025
'Melarsen oxide'	Parent	4 4C	4 3C 1R	4 4C	17 8C 9R	19 1C 15R 3N
	Resistant	4 4C	4 4C	4 3C 1R	4 3C 1R	4 2R 2N

Results shown as follows:
4 1C, 1R, 2N = 4 mice treated; 1 cured (blood permanently cleared of trypanosomes), 1 relapsed (blood temporarily cleared), and 2 not affected (blood not cleared).

Table 1 shows that (*a*) the tryparsamide-resistant offshoot has retained a full measure of resistance, and (*b*) 'Melarsen oxide' is equally as efficacious against the resistant as against the parent strain.

'Melarsen' also was shown, by similar tests, to be equally effective against both strains.

Interference by 'Surfen C'

The commonly used term 'arsenic-resistance', in reference to trypanosomes resistant to aromatic arsenicals such as tryparsamide, 'Atoxyl', 'Mapharside', etc., has long been recognized as a misnomer, since it is the non-arsenical substituted phenyl radical rather than the mere presence of arsenic which may determine whether or not a compound is active against so-called 'arsenic-resistant' trypanosomes. Thus, it has been known since the time of Ehrlich that 'Atoxyl'-resistant trypanosomes are sensitive to arsenophenylglycine and to other aromatic arsenicals containing an acetic acid or carboxyl substituent[6,5,7]. This feature has again been given prominence by Eagle's introduction of γ-(*p*-arsenosophenyl)butyric acid, active against tryparsamide-resistant trypanosomes[8]. King and Strangeways[7] suggested that such carboxyl-substituted arsenoxides differ from others in their mode of fixation on, or entry into, the trypanosome cell, while the ultimate lethal mechanism (presumably an inactivation of essential —SH groups) is the same for all types of arsenoxide. We have provided further circumstantial support for this view in arguments depending on the finding that *p*-aminobenzoic acid interferes with the trypanocidal action of Eagle's compound but not with that of 'Mapharside', while glutathione interferes with the action of both[9].

With the demonstration of 'Melarsen oxide' as a representative of a further class of arsenoxide active against tryparsamide-resistant trypanosomes, it became of interest to find out whether suitable interference experiments might provide similar circumstantial evidence for the view that this type of

arsenoxide also differs from others in its mode of fixation on the trypanosome cell, but not in the essential mechanism of its lethal effect.

The obvious type of compound in which to seek for the property of selective interference with 'Melarsen oxide' would be a substance containing the melamine nucleus. Such a compound is 'Surfen C', bis(2-methyl-4-amino-6-quinolyl)melamine [III], which is itself a chemotherapeutic agent of significant activity against *T. congolense* and *T. brucei*[10]. It also exercises some action on our strain of *T. rhodesiense*. In the experiments below, mice were infected with the parent strain of *T. rhodesiense* and treated under the standard conditions of timing and degree of infection mentioned above; in these circumstances more than 24 hours elapse before the blood becomes free of trypanosomes after treatment with 'Surfen C' even in maximal doses.

Table 2 gives the results of a number of interference experiments and shows that while *p*-aminobenzoic acid interferes selectively with Eagle's compound, 'Surfen C' interferes similarly with 'Melarsen oxide'.

TABLE 2. SELECTIVE INTERFERENCE: *p*-AMINOBENZOIC ACID AGAINST γ-(*p*-ARSENOSOPHENYL)BUTYRIC ACID (EAGLE'S COMPOUND), AND 'SURFEN C' AGAINST 'MELARSEN OXIDE'

Treated with (intraperitoneally)	Main treatment preceded 5 min. by		
	—	*p*-Aminobenzoic acid (70 mgm./20 gm.)	'Surfen C' (4 mgm./20 gm.)
'Mapharside' 0·015 mgm./20 gm.*	cl	cl	cl
Eagle's compound 0·015 mgm./20 gm.*	cl	n	cl
'Melarsen oxide' 0·003 mgm./20 gm.*	cl	cl	n

Each cell of the table represents results of treating at least eight mice.
*ED_{99}, that is, dose causing temporary disappearance of trypanosomes from the blood in 95 per cent of mice (estimated by probit analysis of numerous trials).
cl = blood cleared of trypanosomes in 24 hours.
n = blood not cleared of trypanosomes in 24 hours.

Other tests showed that glutathione interferes equally with the action of 'Melarsen oxide' and of the other arsenoxides. If, then, glutathione interference be accepted as evidence that the essential mechanism of lethal action is by interference with —SH constituents of the parasite cell[11], we may conclude that 'Melarsen oxide' (like Eagle's compound) shares this mode of action with other arsenoxides, but that it differs in its fixation on, or route of entry into, the trypanosome, this fixation or route being selectively blocked by 'Surfen C'.

It is reasonable to suppose that it is the melamine nucleus of 'Surfen C' which determines the selective nature of its interference with 'Melarsen oxide'. If this were so, then no such selective interference should be exercised by 'Surfen' [IV], which differs from 'Surfen C' by having a carbamide instead of a melamine linkage between the two quinoline systems[10]. This anticipation was substantiated by interference experiments in respect of 'Surfen' and the three arsenoxides. It was found, however, by examining the blood at hourly intervals within eight hours of treatment, that instead of complete absence of any interference with the three arsenicals (as found in similar tests of 'Surfen C' with 'Mapharside' and Eagle's compound, respectively), 'Surfen' does exercise some degree of interference with each of the three arsenicals. The significance of this non-specific interference will be elaborated elsewhere, but meanwhile it is established that the interference of 'Surfen C' operates selectively against 'Melarsen oxide', and presumably depends on the presence of the melamine system in both compounds*.

The facts, therefore, warrant the view that while the ultimate lethal mechanism of 'Melarsen oxide' is the same as that of other arsenoxides (by inactivation of —SH groups, perhaps of the pyruvate oxidase system[12]), it has a radically different means of fixation on, or entry into, the trypanosome cell, and it is this difference which may underlie the fact that it is active against trypanosomes resistant to the more usual type of arsenical. We have recently reached a similar conclusion in connexion with antimalarials. Representatives of the earlier pyrimidine prototypes of 'Paludrine', such as 3349[13], are active against 'Paludrine'-resistant *P. gallinaceum*, and we have connected this finding with the conception that the pyrimidine precursors of 'Paludrine' share with the latter a common (but unknown) ultimate mode of lethal action on the malaria parasite, while differing in their mechanisms of attachment to, or entry into, the parasite cell[14].

This work was supported by grants from the Medical Research Council. We are obliged to Messrs. Parke Davis and Co. for supplies of 'Melarsen' and 'Melarsen oxide'.

* *Note added in proof.* This supposition has been further supported by finding that melamine itself interferes with the therapeutic action of 'Melarsen oxide', but not of 'Mapharside' or Eagle's compound.

[1] Friedheim, E. A. H., *Ann. Inst. Past.*, **65**, 108 (1940).
[2] Friedheim, E. A. H., *J. Amer. Chem. Soc.*, **66**, 1775 (1944).
[3] Weinman, D., and Franz, K., *Amer. J. Trop. Med.*, **25**, 343 (1945).
[4] Van Hoof, L., *Trans. Roy. Soc. Trop. Med. Hyg.*, **40**, 727 (1947).
[5] Yorke, W., and Murgatroyd, F., *Ann. Trop. Med. Parasitol.*, **24**, 449 (1930).
[6] Ehrlich, P., *Arch. f. Schiffs.-u. Trop. Hyg.*, 13 Bhft., 321 (1909).
[7] King, H., and Strangeways, W., *Ann. Trop. Med. Parasitol.*, **36**, 47 (1942).
[8] Eagle, H., *Science*, **101**, 69 (1945).
[9] Williamson, J., and Lourie, E. M., *Ann. Trop. Med. Parasitol.*, **40**, 255 (1946).
[10] Ienesch, H., *Ang. Chem.*, **50**, 891 (1937).
[11] Voegtlin, C., Dyer, H. A., and Leonard, C. S., *Pub. Health Rep. Wash.*, **38**, 1882 (1923).
[12] Peters, R. A., Stocken, L. A., and Thompson, R. H. S., *Nature*, **156**, 616 (1945).
[13] Curd, F. H. S., Davey, D. G., and Rose, F. L., *Ann. Trop. Med. Parasitol.*, **39**, 157 (1945).
[14] Williamson, J., and Lourie, E. M., *Ann. Trop. Med. Parasitol.*, **41**, 278 (1947).

INTERNATIONAL STUDY OF RHEOLOGY

International Joint Committee on Rheology

IN December 1945 the International Council of Scientific Unions instituted a Joint Committee on Rheology, with representatives of the International Unions for Physics, Chemistry, Biological Sciences, and Geodesy and Geophysics, to which afterwards was added the International Union for Theoretical and Applied Mechanics. The International Union of Physics will act as 'mother union' for this Committee.

The Committee held its first meeting during September 8–9, 1947, in London. It was decided that its terms of reference should be to co-ordinate research and to investigate problems concerning the deformation and the flow of matter, and the following were nominated as officers for the year 1947–48: *Chairman*, Dr. Th. von Karman, Pasadena, Cal.; *Vice-chairman*, Mme. A. Dobry-Duclaux, Paris; *Secretary*,

Dr. J. M. Burgers (van Houtenstraat 1, Delft, Holland); *Committee*, P. Eggleton, H. Eyring, A. Frey-Wyssling, G. van Iterson, jun., G. W. Scott Blair, R. Signer and Sir Geoffrey Taylor. The Committee intends to act as a central body for establishing contact between scientific men and societies engaged upon work in rheology. For this purpose it has chosen the following subjects for its initial activities: nomenclature; abstracting work in rheology; standards of high viscosity. A report on the nomenclature of deformations, prepared in Holland during the War under the auspices of the Committee for the Study of Viscosity and Plasticity of the Royal Netherlands Academy of Sciences (Amsterdam), was considered at the meeting. This report, after modification as a result of discussion, will be submitted both to the members of the Committee and to co-operating societies and groups, with an invitation to send in criticisms and, if desired, new proposals.

As regards abstracting work in rheology, a report will be prepared on what is already being done in this subject, and contact will be established with the United Nations Educational, Scientific and Cultural Organisation. Finally, information will be collected on materials suitable as standards of viscosity of the order of 10^4 poise and more.

International Rheological Congress

An International Rheological Congress will be organised by a Dutch committee, to be held in Scheveningen (near The Hague), during September 21–25, 1948. The Joint Committee intends to hold a meeting during this Congress, at which the information gathered can be discussed and eventually brought before the Congress. The provisional programme includes the following topics: recent developments in the theory of viscosity; nomenclature; fundamental experimental methods; solutions of macromolecular substances; Russian work on rheology; relations between stress and strain in complicated systems; abnormal substances and abnormal phenomena of flow; psycho-physical aspects of rheology; rheological problems in biology; rheology in industry.

An agreement has been reached with the Elsevier Publishing Company, Inc., of Amsterdam, to publish the Proceedings of the Congress in book form. Preprints of all papers will be forwarded to participants at least a month in advance of the Congress. Remarks in discussion will be included in the final edition of the Proceedings. Those intending to present papers should communicate with the principal secretary, Dr. R. Houwink, Rubber-Stichting, Julianalaan 134, Delft, Holland. Manuscripts must be received before May 1, 1948. A maximum of 3,000 words, formulæ and diagrams included, should not be exceeded, and the organising committee must, in consequence of present restrictions, reserve the right to cut down papers.

It is proposed that in the sectional meetings every speaker will give only a short account of his paper or mention the most important points, so that ample time will be available for discussion. The time to be allotted to each paper, inclusive of discussion, will be at most thirty minutes, but may perhaps have to be reduced if many papers are presented.

Due to generous support from Dutch industry and from some Dutch scientific societies, it will be possible to fix the Congress fee for participants at approximately f. 10 (£1), which it is hoped will also cover the cost of the preprints. It does not, however, include the price of the final edition of the Proceedings, which can be fixed only when all papers have been received. The organising committee will assist in obtaining accommodation at Schevingen.

The members of the organising committee are: J. M. Burgers (*Chairman*), R. Houwink (*Principal Secretary*), H. Kramers, A. J. Staverman, R. N. J. Saal, A. van Rossem, H. C. den Daas.

RESULTS OF THE CONTINUOUS USE OF AN AMMONIUM PHOSPHATE FERTILIZER ON RICE IN LOWER BURMA

By D. RHIND, O.B.E., and U TIN
Dept. of Agriculture, Burma

CULTIVATORS in parts of the Irrawaddy delta complained that after a few years use of an ammonium phosphate fertilizer on rice lands, they had continually to increase the dose in order to obtain the same response. An experiment was devised to test this opinion[1,2].

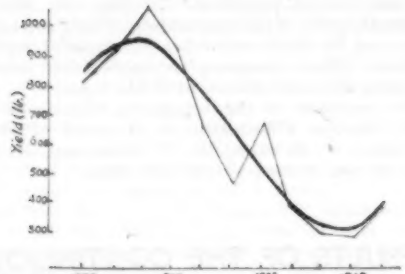
A proprietory ammonium phosphate fertilizer, the one complained of, was applied repeatedly for eleven years to a series of plots replicated five times on Myaungmya Farm in the Irrawaddy delta. The experiment continued from 1930 until 1940 inclusive, when it was interrupted by the War. The soil is a recent, acid alluvium; the rainfall averaged 93·14 in. a year during the period of the experiment; the variety of rice was the pure line *Ngasein* C14–8. The soil analysis is given in Table 1.

TABLE 1. MYAUNGMYA FARM SOIL

Insoluble residue	68·82		
Soluble silica	0·01	Stones, gravel and fine gravel	nil
Ferric oxide (Fe_2O_3)	6·06	Coarse sand	1·1
Alumina (Al_2O_3)	10·95	Fine sand	8·4
Lime (CaO)	0·15	Silt	24·6
Magnesia (MgO)	0·63	Fine silt	54·7
Potash (K_2O)	0·25	Clay	11·5
Soda (Na_2O)	0·14		
Sulphuric acid (SO_3)	0·15		
Phosphoric acid (P_2O_5)	0·01		
Carbon dioxide	0·08		
Organic matter-combined water	8·16		
Moisture lost at 100° C.	4·55		
Manganese oxide (Mn_3O_4)	0·04		
Organic carbon	1·85		
Organic nitrogen	0·15		
Available P_2O_5	0·0016		
Available potash	0·0137		
*p*H	5·3		

The fertilizer contained 18·20 per cent of nitrogen and 18·43 per cent of P_2O_5, and was applied at the rate of 100 lb. per acre shortly before transplanting. Cultivation methods were those normal to the area, seedlings being raised in unmanured nurseries and transplanted. Rice in the Irrawaddy delta is grown continuously without rotation as a single monsoon crop.

In every year the yields of the manured plots were significantly higher than the unmanured, and this is the normal effect of ammonium phosphate fertilizers on soils of this type. The point which the following analysis brings out, and which is important, is that after the first few years there was a decline in the response to the fertilizer, though at the end of the experiment there was still a significant increment over the unmanured plots.



DIFFERENCES IN YIELD OF PADDY GRAINS OF TREATED AND UNTREATED SOILS, 1930–40 (IN LB.); THIRD DEGREE POLYNOMIAL. SMOOTH CURVE, CALCULATED; STRAIGHT LINES, OBSERVED

A polynomial of the third degree (see graph) has been fitted to the variability of the differences between the yields per acre of the treated and untreated plots. The calculated differences agree well with those found (Table 2).

TABLE 2. CALCULATED AND ACTUAL DIFFERENCES IN YIELD OF PADDY PER ACRE OF MANURED AND UNMANURED PLOTS. MYAUNGMYA FARM

Year	Actual differences over control in lb. per acre	Calculated differences over control in lb. per acre
1930	808	833·8
1931	908	932·4
1932	1062	939·7
1933	928	878·4
1934	647	771·2
1935	470	640·7
1936	695	509·7
1937	413	400·6
1938	332	336·4
1939	321	339·5
1940	431	432·6

The total variance contributed by the variation in differences in yield from year to year has been analysed into (1) the amount due to average rate of deterioration, (2) slow changes other than steady deterioration, and (3) annual causes. The smoothed curve shows the actual course and extent of the slow changes in mean differences in yields. The analysis of variance is given in Table 3.

TABLE 3. ANALYSIS OF VARIANCE

Sources of variation	Degrees of freedom	Sum of squares	Mean variance	F
Deterioration	1	498491·06	498491·06	35·52
Slow changes	2	88108·66	44054·38	3·139
Annual fluctuation	7	98228·46	14032·64	

The variation due to deterioration (represented by a linear function) is significant, but that due to slow changes is not reliably greater than the residual variance. The secular changes in yield differences examined are given in Table 4. The measures x_3', x_3', and x_4' of the component of change can be compared with the residual *S.D.*

TABLE 4. SECULAR CHANGES IN YIELD DIFFERENCES

Component	lb. per acre
Mean difference	+ 637·7
x_2'	− 706·0
x_3'	− 8·8
x_4'	+ 296·7
S.D.	± 118·4

The linear regression coefficient is − 67·3 ± 13·7 lb. per acre per year.

After an initial rise in the first three years, the yield differences significantly decreased during the remainder of the period of eleven years when the fertilizer was repeatedly applied. We refrain from speculation on the causes of this result. The cultivators were justified in their complaint. There is clearly need for caution before advocating the prolonged use of artificials without thorough tests in the field, and for further investigation into the causes of the present results. Conclusions based on incomplete results as reported in the Myaungmya Farm Reports from 1931 to 1941 are erroneous.

[1] Ann. Rept. Dept. Agric. Burma, 1941–42 and 1942–43, 2.
[2] Agric. Dept. Burma, Myaungmya Farm Reports, 1931 to 1941.

NUTRITION AND CANCER

A SYMPOSIUM arranged by the New York Academy of Sciences and held in December 1946 on "Nutrition in Relation to Cancer" covered a wide field and included a number of interesting articles which have now been published*. The paper by Dr. E. L. Tatum on chemically induced mutations and their bearing on carcinogenesis deals mainly with mutations induced in *Neurospora* and *Escherichia coli*, where the mutations have made the organisms more exacting in their nutritional requirements. Dr. W. J. Robbins, dealing with the botanical contributions to the cancer problem, suggests that the autonomous growth of plant tumours induced by *Phytomonas tumefaciens* is due to their ability to produce indole-acetic acid. In discussing the nutrition of tissue cultures, Dr. P. R. White indicates that if mammalian cells could be grown in controlled synthetic media, then the nutritional techniques used in the study of mutations in *Neurospora* could be applied to cancer tissue and carcinogenesis. This might give more insight into the relation of carcinogenesis and mutations involving changes in nutritional requirements.

The induction of cancer in animals is often greatly affected by diet. Dr. A. Tannenbaum describes how the restriction of the calorific intake of animals reduces the incidence of spontaneous mammary tumours, lung adenomas, hepatomas, sarcomas, and skin tumours, in mice treated with 3 : 4-benzpyrene. Restriction of calorific intake, however, has little effect on growth of established cancer. Perhaps the most interesting results of the effect of diet on carcinogenesis are seen in the experiments on hepatoma induction with azo dyes. Such experiments, carried out at Wisconsin, are described by Dr. J. A. Miller, and results obtained at the Memorial Hospital by Dr. C. J. Kensler. A high content of riboflavin in the liver reduces the chance of tumour development. Treatment with carcinogenic azo dyes tends to reduce the riboflavin content of the liver; but the carcinogenic action can be neutralized by adding riboflavin to the diet. Dr. J. White, Dr. F. R. White and Dr. G. B. Mider find that the incidence of leukæmia in mice treated with methylcholanthrene is not reduced if the dietary lysine or tryptophane is reduced to levels which prevent growth. On the other hand, reduction of the cystine intake to such a level did reduce the incidence of leukæmia in mice treated with methylcholanthrene.

Two independent groups of workers in the United States have produced tumours in rats by feeding choline-deficient diets. Dr. R. W. Engel, Dr. D. H. Copeland and Dr. W. D. Salmon of Alabama describe pathological changes including cancers which were seen in the lungs, liver, subcutaneous tissue, pancreas

* "Nutrition in Relation to Cancer", by Charles Glen King, John J. Bittner, D. H. Copeland, R. W. Engel, C. J. Kensler, George W. Kidder, G. Burroughs Mider, J. A. Miller, Harold P. Morris, William J. Robbins, W. D. Salmon, Albert Tannenbaum, E. L. Tatum, Florence R. White, Julius White and Philip R. White, *Ann. New York Acad. Sci.*, **49**, Art. 1, 1–140.

and bladder in fourteen out of eighteen rats maintained on such low choline diets for five to eleven months.

Although it may seem disappointing that after so much study of cancer the fundamental cause or nature of it is unknown, the papers referred to above show advances. The carcinogenic process can often be influenced by diet, which means that the process can be resolved into separate parts, and this must help in the understanding of the process. Many of the speakers at the symposium compared carcinogenesis to mutations. Both cancer and mutations can be induced in living organisms by similar agents. The hypothesis that cancer is a somatic mutation relates carcinogenesis to other biological changes and the stability of the nuclear and cytoplasmic genes.

E. BOYLAND

SURVEY OF RADIO NOISE

IT has long been appreciated that satisfactory radio communication depends upon the establishment at the receiving station of a minimum strength of signal above the prevailing noise. During the War, it became clear that the study of atmospheric noise-level and the limitation which it imposes on signal reception has received far less attention in recent years than the study of radio wave propagation. In 1943, the Radio Research Board, in co-operation with British inter-Service organisations, considered that it was desirable to supplement our existing knowledge of the nature, origin and prevalence of atmospherics, with particular reference to their effect on radio reception in various parts of the world. It was recognized that this would involve the carrying out of a long-term programme of research in order to place our knowledge on a satisfactory basis in relation to other advances in radio reception technique. Before embarking upon such long-term research, the Board recommended that a survey of existing knowledge in this field should be made as soon as possible; and it is in consequence of this recommendation that Radio Research Special Report No. 15, entitled "Survey of Existing Information and Data on Radio Noise over the Frequency Range 1–30 Mc./s.", has recently been published by the Department of Scientific and Industrial Research (London: H.M. Stationery Office. 3*s.* net).

This report has been prepared in the Radio Division of the National Physical Laboratory by Dr. H. A. Thomas and Mr. R. E. Burgess. Some 180 published papers on the subject were examined, together with data and measurements made available by certain commercial and government organisations operating radio services in Great Britain. The report covers radio noise of all types, whether of atmospheric, cosmic or man-made origin; but the scope of the work has been limited to radio frequencies between 1 and 30 Mc./s. (wave-lengths 10–300 metres), since most of the medium- and long-distance communication and broadcasting is conducted within this range, and the efficiency of such services is determined and even severely limited by the strength of the noise prevailing at the receiving station.

In most circumstances, atmospheric noise is the main factor limiting long-distance reception and communication; all thunderstorms, with their accompanying lightning flashes, within a range of several thousand miles are potential sources of disturbance. The most prominent centres of such storms are the large land areas, and particularly those in the tropics such as Africa and America during their local summer seasons, although these storm centres can drift out over the oceans to considerable distances. In each locality the thunderstorm activity varies with the season and during the day, and it is usually greatest under summer conditions and during the local afternoon. But the radio waves originating in a lightning flash can travel to great distances and may cause considerable disturbance at a receiving point where the above conditions do not apply.

The report deals also with the measurement of the strength of noise and its direction of arrival, and it is in these fields that active research is now in progress with the view both of obtaining a better understanding of the origin and nature of radio noise of all types, and also of developing techniques of limiting or mitigating the effects of these disturbances to radio communication. Such investigations are now being started in various parts of the world, and this report provides a good foundation as a comprehensive presentation of existing knowledge.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, January 19

ROYAL PHYSICAL SOCIETY OF EDINBURGH (at the Royal Scottish Geographical Society, Synod Hall, Castle Terrace, Edinburgh), at 5.15 p.m.—Dr. James Davidson: "Biology and the Detection of Crime".

CHEMICAL SOCIETY, SOUTH WALES SECTION (joint meeting with the UNIVERSITY COLLEGE OF SWANSEA STUDENTS' CHEMICAL SOCIETY, at University College, Swansea), at 6 p.m.—Dr. Philipp Gross: "The Physical Chemistry of some Vacuum Metallurgical Processes".

INSTITUTE OF WELDING, NORTH LONDON BRANCH (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Mr. S. M. Reisser: "The Welding of Bridges and Buildings".

Tuesday, January 20

ROYAL SOCIETY OF ARTS, DOMINIONS AND COLONIES SECTION (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. A. T. Newboult: "Reconstruction in Malaya".

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (in the Physical Chemistry Department, Royal College of Science, Imperial Institute Road, London, S.W.7), at 2.30 p.m.—Dr. S. J. Rowland: "Recent Studies in the Composition of Milk".*

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5 p.m.—Mr. John M. Mogey: "The Community in Ulster".

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. H. Harris: "Sex Limitation in Human Genetics".*

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, London, S.W.1), at 5.30 p.m.—Symposium of Papers on "Winter Conditions and the Civil Engineer". (Mr. Stanley Mehew: "Roads"; Mr. W. K. Wallace: "Railways"; Mr. H. J. B. Manzoni: "Municipal"; Mr. Ben Howorth: "Drainage and Inland Navigation"; Prof. D. Brunt, F.R.S.: "Meteorology".)

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "To What Extent does Distortion Really Matter in the Transmission of Speech and Music?" (to be opened by Mr. P. P. Eckersley).

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. C. H. Desch, F.R.S.: "Abrasion, Erosion and Corrosion".

INSTITUTION OF THE RUBBER INDUSTRY (at Caxton Hall, Caxton Street, London, S.W.1).—"Industrial Design in the Rubber Industry".

Wednesday, January 21

ROYAL MICROSCOPICAL SOCIETY (in the Hastings Hall, B.M.A. House, Tavistock Square, London, W.C.1), at 5 p.m.—Annual Meeting; Dr. R. J. Ludford: "Relation between Cellular Structure and Functional Activity" (Presidential Address).

INSTITUTION OF ELECTRICAL ENGINEERS, TRANSMISSION SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. E. T. Norris: "The Lightning Strength of Power Transformers".

BRITISH INSTITUTION OF RADIO ENGINEERS, SCOTTISH SECTION (at the Heriot-Watt College, Edinburgh), at 6.30 p.m.—Mr. W. D. Oliphant: "Acceleration of Sub-Atomic Particles".

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND SOUTH-EASTERN COUNTIES SECTION (at the Wellcome Research Institution, 183 Euston Road, London, N.W.1), at 6.30 p.m.—Dr. H. N. Linstead: "Science and Parliament".

SOCIETY OF DYERS AND COLOURISTS, MIDLANDS SECTION (at the King's Head Hotel, Loughborough), at 7 p.m.—Mr. G. C. Grundy: "Non-Textile Uses of Dyestuffs".

CHEMICAL SOCIETY, EIRE SECTION (joint meeting with the IRISH CHEMICAL ASSOCIATION, in the Department of Chemistry, Trinity College, Dublin).—Prof. Wesley Cocker: "Santonin".

Thursday, January 22

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

LONDON MATHEMATICAL SOCIETY (at University College, Gower Street, London, W.C.1), at 5 p.m.—Mr. A. D. Booth: "Recent Developments in Electronic Computing".

MINERALOGICAL SOCIETY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5.15 p.m.—Scientific Papers.

INSTITUTION OF ELECTRICAL ENGINEERS, INSTALLATIONS SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. B. Feldbauer: "The Design of Contactors with regard to their Industrial Application".

CHEMICAL SOCIETY, NOTTINGHAM SECTION (in the Chemistry Lecture Theatre, University College, Nottingham), at 6 p.m.—Prof. Brynmor Jones: "Some Aspects of Aromatic Substitution".

SOCIETY OF DYERS AND COLOURISTS, WEST RIDING SECTION (at the Great Northern Victoria Hotel, Bradford), at 7.15 p.m.—Prof. J. B. Speakman: "The Formation of Polymers in Wool".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

CHEMICAL SOCIETY, EDINBURGH SECTION (joint meeting with the LOCAL SECTIONS OF THE ROYAL INSTITUTE OF CHEMISTRY and the SOCIETY OF CHEMICAL INDUSTRY, at the North British Station Hotel, Edinburgh), at 7.30 p.m.—Dr. H. T. Openshaw: "Some Recent Developments in Alkaloid Chemistry".

Friday, January 23

MINERALOGICAL SOCIETY, CLAY MINERALS GROUP (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 10 a.m.—Discussion on "Clay Minerals as Catalysts".

CHEMICAL SOCIETY, SOUTHAMPTON SECTION (joint meeting with the SOUTHAMPTON UNIVERSITY COLLEGE CHEMICAL SOCIETY, in the Physics Lecture Theatre, University College, Southampton), at 5 p.m.—Prof. E. C. Dodds, F.R.S.: "Synthetic Organic Chemistry in relation to Biology".

UNIVERSITY COLLEGE LONDON (in the Department of Physiology Theatre, Gower Street, London, W.C.1), at 5 p.m.—Dr. E. Ashworth Underwood: "The Heritage of Medicine" (further lectures on January 30, February 6, 13, 20 and 27).*

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Mr. T. A. Crowe: "Gas Turbine and Marine Propulsion" (Thomas Lowe Gray Lecture).

MANCHESTER STATISTICAL SOCIETY, STATISTICAL METHODS STUDY GROUP (in the Society of Architects' Room, Textile Institute, 16 St. Mary's Parsonage, Manchester), at 5.45 p.m.—Mr. J. R. Jarmain: "Density Standards in Assessing Housing Needs".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion on "The Growing Points in Science" (to be opened by Prof. J. S. Mitchell and Dr. K. Weissenberg).

Saturday, January 24

BIOCHEMICAL SOCIETY (at the British Postgraduate Medical School, Ducane Road, London, W.12), at 11 a.m.—Scientific Papers and Demonstrations.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

DIRECTOR of a new Vegetable Research Station—The Chairman, Organising Committee, Vegetable Research Station, Ministry of Agriculture, Block 4, Bickenhall Mansions, Baker Street, London, W.1 (January 24).

SENIOR LECTURER IN PHYSICS AND ELECTRONIC ENGINEERING at the Ministry of Supply School of Electronics—The Chief Superintendent, Telecommunications Research Establishment, Great Malvern, Worcs., quoting 5/138/JFA (January 24).

ENGINEER IN THE AUDIO FREQUENCY SECTION of the Research Department in London, ENGINEERS (2) IN THE FIELD STRENGTH SECTION of the Research Department at Oxford, and SENIOR AND JUNIOR ENGINEERS IN THE DESIGNS DEPARTMENT in London—The Engineering Establishment Officer, B.B.C., Broadcasting House, London, W.1 (January 24).

SENIOR LECTURER IN AERODYNAMICS, a SENIOR LECTURER IN MATHEMATICS, a RESPONSIBLE LECTURER IN ELECTRICAL ENGINEERING, a LECTURER IN MECHANICAL ENGINEERING, a LECTURER IN PRODUCTION ENGINEERING, and a TEACHER OF ENGINEERING DRAWING—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (January 24).

RESEARCH PHYSICIST—The Director, Institute for Industrial Research and Standards, 45 St. Stephen's Green, Dublin (January 24).

POWER STATION CHEMIST—The Borough Electrical Engineer and Manager, Halifax Electricity Department, 19–23 Northgate, Halifax (January 26).

SOIL CONSERVATION OFFICERS in the Soil Conservation Branch of the Irrigation Department, Southern Rhodesia—The Office of the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (January 31).

SENIOR LECTURER OR LECTURER IN THE DEPARTMENT OF PHYSIOLOGY—The Registrar, The University, Sheffield (February 7).

LECTURER IN CHEMISTRY at Auckland University College, New Zealand—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (February 21).

CHAIR OF PATHOLOGY in the University of Cape Town—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (February 21).

CHAIR OF MATHEMATICS at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 24).

READERSHIP IN BACTERIOLOGY at St. Thomas's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 26).

SENIOR PROFESSIONAL OFFICER in the Tobacco Branch of the Division of Agriculture and Lands, Southern Rhodesia—The Secretary, Office of the High Commissioner for Southern Rhodesia, Rhodesia House, 429 Strand, London, W.C.2 (February 27).

ASSISTANT KEEPER (Class II) IN THE DEPARTMENTS OF (*a*) PHYSICS AND GEOPHYSICS, (*b*) CHEMISTRY, ASTRONOMY AND OPTICS, (*c*) INDUSTRIAL ENGINEERING, (*d*) AIR AND WATER TRANSPORT, (*e*) SCIENCE LIBRARY—The Director and Secretary, Science Museum, South Kensington, London, S.W.7, endorsed 'Assistant Keeper' (February 28).

LECTURER IN GEOGRAPHY at Raffles College, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 8 Park Street, London, W.1 (February 28).

CHAIR OF AGRICULTURE in the University of Ceylon—The Secretary, Inter-University Council for Higher Education in the Colonies, 8 Park Street, London, W.1 (February 28).

SENIOR LECTURER IN MECHANICAL ENGINEERING, a SENIOR LECTURER IN AERONAUTICAL ENGINEERING, a SENIOR LECTURER IN CIVIL ENGINEERING, a LECTURER IN ELECTRICAL ENGINEERING, and a LECTURER IN MECHANICAL ENGINEERING, at Auckland University College, New Zealand—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (March 1).

LECTURER IN PHARMACOLOGY at Makerere College, Uganda—The Secretary, Inter-University Council for Higher Education in the Colonies, 8 Park Street, London, W.1 (March 25).

I.C.I. RESEARCH FELLOWSHIPS IN BACTERIOLOGY, BIOCHEMISTRY, CHEMICAL ENGINEERING, CHEMISTRY, CHEMISTRY OF LEATHER MANUFACTURE, CHEMOTHERAPY, COLLOID SCIENCE, COLOUR CHEMISTRY AND DYEING, ENGINEERING (Civil, Electrical or Mechanical), FUEL AND REFRACTORIES, METALLURGY, PHARMACOLOGY, PHYSICS, TEXTILE INDUSTRIES (Protein Chemistry)—The Registrar, The University, Leeds 2 (April 30).

SENIOR LECTURER IN GENERAL BACTERIOLOGY in the University of Sydney—The Secretary Universities Bureau of the British Empire, 8 Park Street, London, W.1 (Sydney, May 1).

TECHNICIAN (Grade B) IN THE PATHOLOGICAL LABORATORY—The House Governor and Secretary, Queen Mary's Hospital for the East End, Stratford, London, E.15.

EXPERIENCED BIOCHEMICAL TECHNICIAN for the Department of Physiology—The Professor of Physiology, Medical School, King's College, Newcastle-upon-Tyne.

CHEMISTS and ASSISTANTS for the development of methods of combating the corrosion of iron and steel—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, endorsed 'Corrosion'.

FIELD ZOOLOGIST in Kenya to undertake work in connexion with a survey of tsetse distribution in the Colony—The Director of Recruitment (Colonial Service), Colonial Office, 15 Victoria Street, London, S.W.1.

JUNIOR LABORATORY TECHNICIAN with experience of simple histological techniques—The Secretary, Marie Curie Hospital, 66 Fitzjohn's Avenue, Hampstead, London, N.W.3.

RESEARCH CHEMIST—The Director of Research, British Leather Manufacturers' Research Association, 1–6 Nelson Square, London, S.E.1.

SENIOR POST IN THE METALLURGICAL DEPARTMENT—The Director, Tin Research Institute, Fraser Road, Greenford, Middx.

GRADUATE IN PHYSICS or ENGINEERING to undertake experimental work in connexion with small heating equipment—The Assistant Secretary, British Coal Utilisation Research Association, 13 Grosvenor Gardens, London, S.W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Experimental Science: a Career for the Practical Boy or Girl. Pp. 20. (London: Institute of Physics, 1947.) [125

Geological Survey of Great Britain. Wartime Pamphlet No. 20: Water Supply from Underground Sources of Cambridge–Ipswich District, Part 10, General Discussion. By Dr. Austin W. Woodland; with a Contribution on Rainfall, supplied by the Director, Meteorological Office, Air Ministry. Pp. ii + 88. 4*s.* **Wartime Pamphlet No. 47: Brick Clays of North-East Scotland, Part 1, Description of Occurrences,** by V. A. Eyles and Dr. J. G. C. Anderson; **Part 2, Report on Analyses and Physical Tests,** by Dr. D. G. R. Bonnell and B. Butterworth. Pp. ii + 88. 4*s.* (London: Geological Survey and Museum, 1946.) [135

Proceedings of the Royal Society of Edinburgh. Section A (Mathematical and Physical Sciences). Vol. 62, Part 3, No. 25: Some Continuant Determinants arising in Physics and Chemistry. By D. E. Rutherford. Pp. 229–236. 1*s.* 6*d.* **Vol. 62, Part 3, No. 26: The Universal Integral Invariants of Hamiltonian Systems and Application to the Theory of Canonical Transformations.** By Dr. Hwa-Chung Lee. Pp. 237–246. 1*s.* 6*d.* (Edinburgh and London: Oliver and Boyd, 1947.) [135